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ABSTRACT

This document consists of the final report and executive summary of a distance education technology study conducted on behalf of the Wisconsin Educational Communications Board (WECB) during 1992-93 in order to provide information to assist the educational institutions of the state in formulating strategic directions for the development of distance education technologies. The main components of the study are: (1) a comprehensive statewide distance education needs analysis; (2) analysis of currently available and future technologies; (3) development of technical alternatives for meeting the identified needs; (4) analysis of and recommendations for the current WECB television and FM interconnect; (5) recommendations for ongoing development of a statewide distance education system; and (6) development of modeling tools and information databases which can be used after the conclusion of the study. Appendices include documentation on: the Wisconsin Overlay Distance Education Network (WODIE), Instructional Television Fixed Service (ITFS) allocations, Wisconsin distance education projects, distance education technology resources, interconnection of the broadcast network and Department of Transportation/Digital Signal Processing microwave system, state tower locations, Wisconsin correctional facilities, library districts, Vocational, Technical and Adult Education locations, 2-year and 4-year University of Wisconsin campus locations, Cooperative Educational Service Agency district offices, network connection diagrams, the migration plan, network decision trees, financial model examples, the study database, and standards. A glossary is also appended. (MES)

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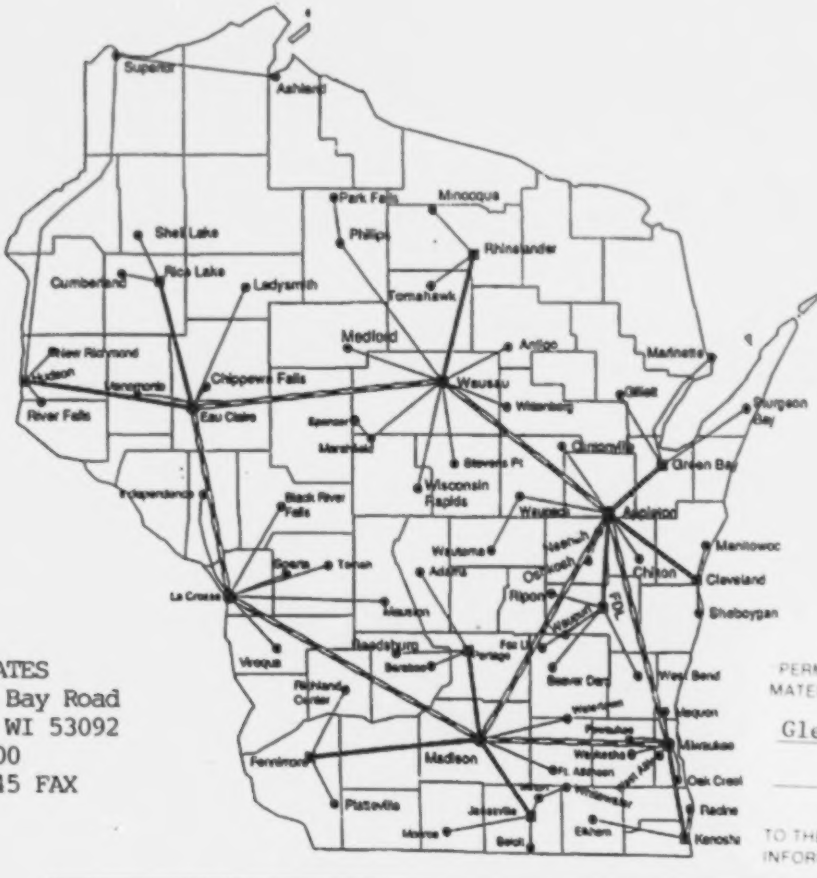
Distance Education Technology Study

Final Report: Executive Summary Presented To: Wisconsin Educational Communications Board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Stevens Pt
Green Bay
Independence
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Waupaca
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Executive Summary

This document presents an executive summary of the *Distance Education Technology Study* conducted by Evans Associates on behalf of the Wisconsin Educational Communications Board (ECB). This study was conducted during the period February, 1992 through June, 1993. The primary purpose was to provide information to assist the educational institutions of the state in formulating strategic directions for the development of distance education technologies.

Distance education systems are already being created locally in many parts of the state. At a time when our educational system is under increased public scrutiny, many educators look to distance education networks as being critical to the future fulfillment of their mission. Their goal is not simply to provide a different method for instruction, but to use technology to enhance and, perhaps, fundamentally change *how we learn* and *how we teach our children*. The motivation for this study was to strive for these goals in an organized fashion statewide, consistent with existing resources and educational objectives.

Many factors must be considered in the planning of a distance education system. Among these are managerial, ownership, operational, and programming issues. This study focused on those issues specifically related to *technology*. The main components of the study were:

- A comprehensive statewide distance education needs analysis;
- Analysis of currently available and future technologies;
- Development of technical alternatives for meeting the identified needs;
- Analysis of and recommendations for the current ECB television and FM interconnect;
- Recommendations for ongoing development of a statewide distance education system;
- Development of modeling tools and information databases which will be updated and maintained after the conclusion of the study.

Section one describes the methods and results of the Needs Assessment phase of the project. Section two summarizes the alternatives considered and the recommendations for meeting the identified needs. The final section outlines a migration and implementation plan for the development of a statewide distance education system.

1. Needs Assessment

This Needs Assessment was conducted during the period March 1, 1992 to May 1, 1992, and then continually refined throughout the remainder of the project. It is important to note that continually advancing technologies cause corresponding changes in perceptions of need. Many factors changed during the course of this study. While the fundamental needs of potential system *users* changed very little, other considerations changed significantly. The awareness, attitudes, and needs of those who might *provide* distance education services (such as educational administrations, government entities, and vendors) did change dramatically over the time period of the study. This section concentrates on the needs of potential users of distance education systems in Wisconsin.

These findings were determined from surveys, interviews, and telephone followups. Among the types of users contacted were representatives from local K-12 school districts, independent colleges and universities, state universities, technical colleges, state governments, local governments, and library systems representing all geographic areas of the state. Many of these contacts worked in the areas of distance education, training, or media coordination. Each institution's contacts were chosen by the institutions themselves, as requested by ECB. A total of 320 institution representatives returned surveys, and 141 group or individual interviews were conducted.

1.1 Key Needs Identified For All Respondents

The following distance education needs were identified as being common to most groups of institutions:

- There is a need for schools to have the outreach capability to offer courses at locations remote from their classrooms. Outreach programs are needed to equalize educational opportunities in currently underserved areas, such as many of the rural areas of the state. Outreach capabilities would also allow schools to share instructional resources, reduce travel time and costs, and reach students who might not otherwise have equivalent educational opportunities (such as working adults, the home-bound, correctional facility inmates, and other non-traditional students).
- There is a need for improved access to professional development courses for nearly all categories of respondents (i.e. continuing education and training for adults, instructors, and agency professionals). This would allow learners to take courses without the excessive time or costs associated with traveling to a campus or training center.
- There is a need for access to library databases and to other data networks.
- There is a need to educate users concerning the capabilities, benefits, and technologies associated with the concept of distance education. There is also a significant need to establish local and state-level planning groups to share expertise and to aid coordination among regions of the state.
- There is a need for a statewide distance education plan which is compatible with the regional distance education systems already operating in the state. Such a plan must not put an unacceptable financial or procedural burden on the user.
- There is a need for the state government to provide assistance to local districts, schools and agencies with respect to funding, grant applications, distance education planning

resources, and technical expertise. Users also require assistance in matters dealing with vendors, RFP creation, evaluation of RFP responses, and contract negotiation.

- There is a need for the establishment of partnerships between educational institutions and private business/industry, in order to provide the businesses with access to educational coursework materials. Access to specialty seminars for professional development are also required. In particular, the health care industry has significant need both for education and for access to computer data networks.

1.2 Specific Needs By Institution Type

Additional key needs were identified for each of the major user groups as follows:

- **K-12 schools** need to access courses for ongoing teacher certification and staff development. In addition, several agencies require electronic access to K-12 student records as well as other data for statistical analysis.
- **CESA offices** need electronic video and data connections between their 12 district offices for training and administrative purposes.
- **VTAE institutions** need to expand their student base via outreach, including connections to the business community. They also require the ability to exchange video, data, and telephone traffic with their branch campuses, with other VTAE institutions, and with regional UW campuses.
- **The University of Wisconsin System**'s four-year institutions require electronic access to state, national, and international resources for faculty research, teaching, communication, and public service. The two-year centers need two-way video connections to each other and to the four-year campuses in order to support administrative activities and expand their curricula. UW-Extension, already a major distance education user, sees needs for program underwriting and the increased availability of continuing education courses. Throughout the UW system, increased faculty and administration awareness and acceptance of distance education is considered crucial to progress.
- **Independent Colleges and Universities** , more than any of the other institutions, have a great need for education, awareness, and planning with respect to distance education issues. A lack of funding has inhibited their progress to date.
- **Libraries** require electronic access to other libraries, databases, and institutions in order to share catalog data and electronically exchange documents.
- **State and local governments'** primary need is the ability to conduct video teleconferences. This ability would reduce costly travel for administrative meetings, staff training, and hearing appearances.

Future state efforts in distance education should be directed towards meeting the above needs. The next section will investigate alternative methods for employing cost-effective delivery systems.

2. Alternatives & Recommendations

The requirements identified in the *Needs Assessment* can only be met via the development of a statewide distance education network. The network must be capable of providing two-way voice, video, and data communications. It must also be capable of providing instructional programming, broadcast programming, staff development programming, and administrative voice and video teleconferencing. This section examines alternatives to the creation of such a network.

2.1 Network Configuration Components

The alternative statewide distance education networks to be explored consist of three basic components: the *overlay network*, *regional networks*, and *local networks*. The overlay network consists of high-capacity "trunk" lines which carry most of the traffic from one part of the state to another (see map attached). The regional network consists of medium-capacity lines which serve to connect local networks to each other and to the overlay network. The local network serves a specific, relatively small area such as a single college campus. Each of these basic systems requires a different level of state involvement, as well as an interface with a distinct category of service provider. For instance, primary responsibility for the overlay network would most properly rest with the state, using appropriate major service providers, while the local loops would generally be the primary responsibility of individual districts or institutions in conjunction with the local telephone companies or cable TV companies. Control of and responsibility for the regional networks should remain with individual institutions and consortia, which feel that they must be the primary control point for their networks.

In analyzing the alternative technologies for each of these components, all of the available technologies which are presently feasible or will become feasible during the planning horizon have been considered.

2.2 Environmental Scan: Experiences of Other States

In Wisconsin, the availability and use of distance education technologies is highly variable; while some local and regional networks have been created, others are hampered by a lack of funding or a lack of expertise. Overall, these local efforts are not being coordinated statewide.

In trying to address similar problems, other states have already established statewide distance education systems. Below are brief descriptions of some of these systems.

- **Iowa** is installing a two-way interactive video overlay system using fiber optic cable; Instructional Television - Fixed Service (ITFS; see section 2.4) is used to reach the end user. This effort is the source of political dissention and lawsuits, primarily because the major carriers were not involved in the planning. Also, many existing resources were not used in the new plan.

- **Indiana** also uses a fiber overlay network and ITFS regional networks. The system works well but, after 12 years, the capacity of the network is too limited and the needed capability of carrying computer data is not part of the network. Satellite is used to add capacity.
- **Minnesota** is planning a fiber state overlay network to connect existing regional networks for the exchange of video and computer data.
- **Washington**'s mixed technology approach to a statewide distance education network is providing an overlay network to connect regional systems at a moderate cost.

2.3 Dismissed Alternatives

Some alternative uses of technology can be summarily discounted:

- **Constructing a completely new state-owned system** (as in Iowa) is not a viable alternative for Wisconsin. In addition to being very costly, executing this option would duplicate facilities and other resources already in place.
- **Buying or leasing fiber optic cable without the associated electronics** (known as buying "dark fiber") allows the customer complete control over the facilities. However, dark fiber is not available from the utilities in Wisconsin. Even if dark fiber were available, an excessive burden would be placed upon the state due to the management and maintenance of the electronics.
- **Not implementing a statewide initiative** would mean that local and regional systems would be allowed to develop at their own pace as funding permits. Such networks would likely be developed to different (and possibly incompatible) technical standards. This option would not meet the identified needs of users statewide. Equalization of educational opportunities across the state would not be achieved. Finally, confining growth to regional systems would not be as cost efficient as would the purchase/lease of statewide facilities from the private sector public utilities because duplication of transportation facilities would occur.

2.4 Technology Discussion

The following is a brief summary of each of the major distance education technologies:

- **Fiber Optic Cable** easily carries two-way voice, video, and data in large capacities over long distances. Fiber in Wisconsin is being installed in great quantities by the utilities and is becoming cost competitive with other technologies.
- **Microwave** has many of the capabilities of fiber but has limited capacity and range. Microwave technology is relatively inexpensive, and can make use of extensive existing tower resources in Wisconsin. Microwave can be used as a migration strategy to bridge gaps in the fiber infrastructure and reduce costs. There are extensive existing microwave

networks within Wisconsin today. The approximate cost of implementing a statewide microwave overlay network would be $12 million. However, the capacity of such a network would be insufficient to meet the projected need within three years.

- **Satellite** is also used extensively today in Wisconsin. It is inherently a one-way medium unless relatively costly uplinks are constructed for two-way applications. Renting satellite time is also expensive compared to other types of media. PBS plans to use satellite heavily for much of its future distance education initiatives because satellite programs can be received virtually anywhere in the country. Emerging technology will allow the use of much smaller dishes than are currently necessary. Satellite time costs approximately $200-$500 per hour for video, and approximately $130 per month for a small data/voice terminal.
- **ITFS** (Instructional Television - Fixed Service) is a form of broadcast television reserved for use by educational institutions. It is inherently a one-way video technology, does not lend itself to computer data transfer and has distance and terrain limitations. Like microwave, tower resources and FCC licensing are required and capacity is limited. ITFS service is relatively inexpensive to establish and is in widespread use throughout the eastern part of the state. It would not be possible to employ ITFS as the only component of a statewide system, partially because of limited channel availability. However, approximately 70% of Wisconsin's population could be served with four to eight channels of one-way video with audio return for approximately $17 million. This solution would not meet all of the identified needs.
- **Cable TV** is also extensively used for local and regional distance education systems. The reliability and availability of cable resources varies widely from one community to another.
- **Education broadcast TV and FM radio** are effective, well-established one-way delivery systems. Expansion can only be done through the use of low power TV stations, and then only in the rural parts of the state.
- Other technologies in use today include **VCR tapes**, **CD-ROM** (i.e. compact discs used to store data), and **telephone systems.**

2.5 Recommendations

Given these technology choices, the following section provides recommendations on technologies best suited for each network element. The contract language and technology standards to be used to obtain these resources from vendors have been evaluated and are discussed in the full text document.

2.5.1 Local Networks

The choice of technology for local networks is usually determined by cost and availability of resources. Although fiber is the best all-around choice, all of the other technologies listed above can reasonably be employed on the local level. Microwave, ITFS and cable TV can be effectively used to reduce the cost of bringing signals to the end user. It is important that local systems be created in a manner that will allow them to be connected to regional and statewide networks.

This study fully supports the idea that local systems should be allowed to make their own decisions regarding technology and local network planning, consistent with the requirement that the ability to connect to other systems is preserved and duplication of equipment is avoided. It is understood that local systems will often involve a mix of technologies obtained both through user purchase and by outside provider leasing.

2.5.2 Regional Networks

Regional networks interconnect geographically dispersed clusters of users. Again, fiber is the recommended best technology choice. However, microwave and ITFS are good alternatives if their respective disadvantages are not a limiting factor. Microwave can be more cost effective than fiber in adding an isolated user to a network. For one-way video, ITFS, satellite, and broadcast TV are all effective. Again, hybrid mixed technology networks can frequently be used to good advantage. Coordination of technology choices and implementation plans at the state level is especially important for regional networks.

2.5.3 State Overlay Network

The recommended state overlay network would serve to interconnect multiple regional networks with voice, video, and data signals. Both fiber optic and microwave systems can be used for this network element. Existing microwave segments could be used today where fiber is not available and where channel capacity is not a problem. Expansion of the existing State Department of Transportation microwave network should be considered for this interim use. After a migration to an all-fiber overlay network in the future, existing microwave systems could be retained to provide alternate routes for some segments of the network (in order to enhance system reliability).

A proposal for a statewide overlay network is provided in this document. This map is based on the locations of schools, existing regional networks, libraries, major hospitals, and existing/planned telephone company switching sites. Note that not all regional/local networks and network endpoints are on the map. Such a network will probably take up to ten years to fully implement, with the primary routes being among the first links to be installed.

2.5.4 TV and FM Interconnect System

Currently, ECB uses microwave facilities to distribute the Wisconsin Public Radio and TV signals to local stations around the state. The lease for these facilities expires in 1994. This study recommends that the existing ECB TV and FM interconnect network be folded into the proposed distance education overlay network as the first step in the implementation of the overlay network. This will allow the same funds to purchase expanded capability, such as two-way connections between the TV stations, stereo sound, and High Definition TV when it is available.

2.5.5 Coordination Of Technical Standards

This report recommends that the state concentrate its efforts on creation of the overlay network while allowing local and regional groups to construct their networks. It is *critically important* that the state take the initiative in developing, adopting, and disseminating comprehensive technical standards to which all local and regional networks must conform. Only by taking this step can the connectability of all networks be assured. Such standards will insure that local users do not purchase substandard facilities. Networks designed exclusively by vendors should be discouraged.

2.5.6 Centralized Leasing

The State Telephone System (STS) is an excellent example of how the buying power of the state can be used to provide local users with excellent telecommunications facilities at the best possible price. This report recommends that the state expand this capability to include high capacity (fiber optic) leasing for use in local and regional voice/video/data networks. If not done, users will continue to sign long term leases for fiber networks at relatively high prices. In some cases, costly duplicated resources will be purchased. In addition, the STS network will lose business as users move their voice traffic to local and regional interconnect systems. By no longer paying STS call charges, local users save money; however, this could result in higher rates for the remaining STS customers.

2.5.7 State Level Expertise Bank

The *Needs Assessment* clearly showed that many users require assistance with respect to distance education technology choices. This study recommends that the state, through the Educational Communications Board, provide consulting services including:

- Technical assistance in understanding distance education technologies;
- Leadership in effecting awareness by and involvement of the state legislature and regulatory agencies;
- Assistance in locating and applying for grant funds;
- Assistance in technology provider RFP generation, RFP response evaluation and contract negotiation;
- Assistance in obtaining facilities at the best possible price (see section 2.5.6 above).

2.6 Order of Magnitude Costs For The Overlay Network

The costs given below are based on knowledge of charges for existing systems in Wisconsin and other states and on budgetary pricing provided by vendors. Where information was incomplete or unavailable, engineering estimates were made based on professional experience. Prices reflect estimates of what might be expected on a statewide project as proposed herein.

A new, total fiber solution providing one video channel and two high-speed data channels to every school, library, and county seat would cost approximately $250 million. However, some of these fiber routes are already in place and being used by local and regional users. If a total fiber solution were implemented, the contracts for these existing routes would need to be bought out. However, this total fiber solution, including the use of fiber for the entire route of the network and connection to the end user, is not recommended by this study.

State funding and construction supervision of the overlay portion of the statewide network would cost approximately $80 to $100 million, including incorporation of existing operating routes. This is the recommended option, which would be the end product of a migration strategy encompassing approximately ten years.

3. Implementation Discussion

This section examines issues surrounding the implementation of the recommendations made in the previous section, and the impact on ECB, other state government agencies, and potential users of the network.

3.1 Migration Plan

It is recommended that implementation of the statewide overlay network and its regional interconnection nodes be made using the following schedule and resources:

- 1993: Establish ECB as the clearinghouse for local and regional system standards and vendor lease terms.
- 1994: Begin creation of the network by issuing an RFP for the TV/FM interconnect which is compatible with the overlay standards and routes. Establish the centralized leasing of high capacity facilities and establish a governance structure for the overlay network.
- 1995: Incorporate public and private state resources into the network, such as the Department of Transportation microwave system and the existing unregulated microwave network infrastructure.
- 1996: Begin connection of VTAE regional systems and UW systems. Incorporate compressed video and high-speed computer networks.
- 1997: Begin connection of K-12 consortiums and state agency traffic.
- 1998: Begin connection of libraries and hospitals.
- 1999: Begin connection of business partners.
- 2000 to 2005: Complete basic network infrastructure.

3.2 Issues And Dependencies

Creation of the network envisioned in this document is dependent on resolution of the following issues identified by the study:

- Obtaining the commitment of the State of Wisconsin, beginning with the Governor's office and the legislature;
- Obtaining the support of other groups and users, such as teachers' unions, citizen groups, and school boards;
- Getting maximum participation of all potential users, so that economies of scale may be achieved;
- Changing the current fiber optic tariffed rate structure used by the PSC, which is hampering fiber system deployment;
- Determining a financing method for the overlay network creation;
- Establishing business partnerships with major employers;
- Making maximum use of existing state facilities, both equipment and people;
- Establishing an administrative body to oversee the network.

3.3 Benefits Of A Statewide Initiative

If these technologies, methods, standards and roles are followed by the state, the result will be a statewide information highway which will meet all of the needs identified in chapter 1. This highway will provide voice, video and data communications within the state and will also allow access to resources nationally and internationally.

Creation of a statewide network will allow all parts of the state and most of its population the opportunity to take advantage of educational and training resources from many diverse sources. Use of an extended two-way videoconferencing ability will reduce travel costs and will allow more employee training than is currently possible.

3.4 Implications To ECB

This study concludes that ECB is the logical and proper state agency to accomplish the tasks outlined in the "Establishment Of Technical Standards" and "State Expertise Bank" sections of this document. In addition, ECB should continue to coordinate the activities of the regional consortia of the state. DPI, CESA, VTAE, UW, and state government agencies should involve ECB in their distance education planning processes.

3.5 The Next Steps

After the conclusion of this study, it is recommended that ECB take the following steps in pursuit of the overall migration strategy outlined earlier:

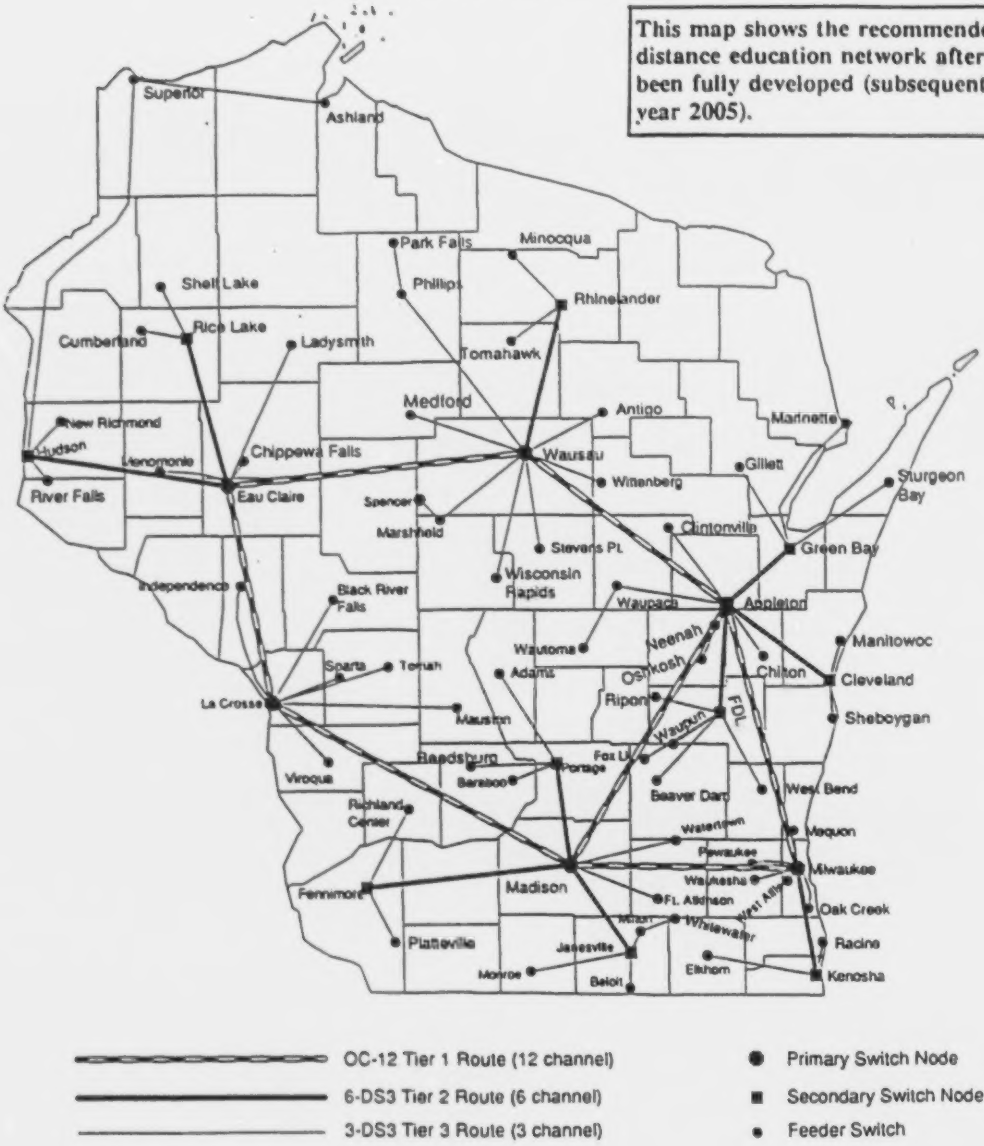
- Determine the staffing impact to ECB and other state agencies of the *clearinghouse* and *centralized leasing* recommendations made in this document.
- Establish ECB as the clearinghouse for network standards and vendor liaison. In both cases, materials provided by this study should serve as starting points for ECB's adoption of technical standards as well as standard vendor contract terms.
- Pursue the required changes in PSC regulations in order to assist in creating affordable fiber distance education networks.
- Maintain liaison with vendors so that users' RFPs reflect the reality of the infrastructure.
- Maintain and update network usage (traffic) studies to assist in future system design.
- Maintain and update the databases which are obtained as deliverables of this study.

This study has raised the level of awareness of distance education issues statewide. A blueprint for the future has been developed. Necessary steps such as the definition of standards, identification of technologies and issues, and migration strategies have been started. It is now incumbent upon the state to build on these results. A network constructed in conformance with these specifications will provide all users with state-of-the-art telecommunications well into the 21st Century.

Wisconsin Overlay Distance Education Network (WODIE)

A Vision For The Future

This map shows the recommended statewide distance education network after it has been fully developed (subsequent to the year 2005).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Minocqua
Phillips
Rhinelander
Shell Lake
Rice Lake
Cumberland
Ladysmith
Tomahawk
Medford
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Marinette
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Hudson
Menomonie
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Mauston
Sheboygan
Waupun
Reedsburg
Fox Lk
Portage
Viroqua
Baraboo
Beaver Dam
West Bend
Richland Center
Watertown
Mequon
Pewaukee
Milwaukee
Waukesha
Fennimore
Madison
Ft. Atkinson
West Allis
Oak Creek
Milton
Whitewater
Platteville
Janesville
Racine
Elkhorn
Monroe
Beloit
Kenosha
OC-12 Tier 1 Route (12 channel)
6-DS3 Tier 2 Route (6 channel)
3-DS3 Tier 3 Route (3 channel)
Primary Switch Node
Secondary Switch Node
Feeder Switch

NOTES: 1) Last mile local loops and individual endpoints are not shown
2) Channels may be used for video, voice or data

Proposed Wisconsin Overlay Distance Education Network

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1993

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Distance Education Technology Study

Final Report

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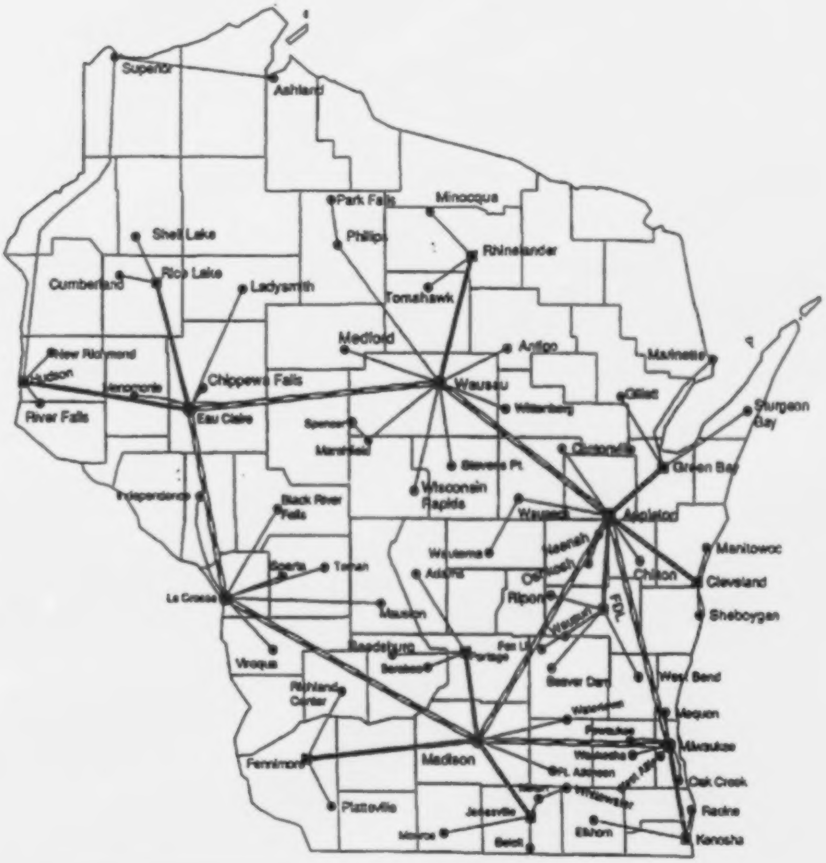
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Rice Lake
Cumberland
Ladysmith
Tomahawk
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New Richmond
Hudson
Menomonie
Chippewa Falls
Wausau
Gillett
Wittenberg
Sturgeon Bay
River Falls
Eau Claire
Spencer
Marshfield
Clintonville
Stevens Pt.
Green Bay
Wisconsin Rapids
Independence
Black River Falls
Waupaca
Appleton
Neenah
Manitowoc
Wautoma
Oshkosh
Chilton
Sparta
Tomah
Adams
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1. Introduction

1.1 Objectives Of The Document

This document is the final report for the *Distance Education Technology Study* conducted by Evans Associates on behalf of the Wisconsin Educational Communications Board (WECB). This study was conducted during the period February, 1992 to June, 1993. The main purpose of this study is to provide information which will assist the educational institutions of the state in formulating strategic directions for the development of distance education technologies. The main components of the study are:

- A comprehensive statewide distance education needs analysis.
- Analysis of currently available and future technologies.
- Development of technical alternatives for meeting the identified needs.
- Analysis of and recommendations for the current WECB television and FM interconnect.
- Recommendations for ongoing development of a statewide distance education system.
- Development of modeling tools and information databases which can be used after the conclusion of the study.

The primary goal of the Distance Education Technology study was to determine statewide user needs and provide recommendations for meeting those needs.

Users who are not familiar with many of the terms used in distance education discussions may wish to reference the *Glossary Of Terms* (Appendix S).

For the purposes of this document, we will use the term *distance education* to mean instruction that takes place in a setting where the teacher is in contact with a student or groups of students by means of correspondence or telecommunication technologies. These technologies are often used to link students and teachers within or between educational districts on an intrastate, interstate or even international basis.

2. Needs Assessment

2.1 Introduction

The needs assessment invited the participation of virtually all educational entities in the state, as well as government and libraries.

This chapter describes the results of the *Distance Education Technology Needs Assessment* conducted by Evans Associates on behalf of the Wisconsin Educational Communications Board. The results stated in this chapter represent a summary of the information gathered from numerous types of educational and governmental institutions representing all regions of the state. Specifically, the following user contacts were made during the first half of 1992:

- All 12 CESA offices.
- All 16 VTAE districts.
- All 26 UW four-year and two-year campuses.
- The UW-Extension.
- 82% of the seventeen library systems.
- 67% of the state's independent colleges.
- 42% of the local K-12 school districts.
- Several pertinent state and local government agencies.

The conclusions reached herein were partially based on written survey responses and interviews.

At each institution, efforts were made to contact those individuals who were the most knowledgeable and/or responsible for the distance education efforts at their location. These contact individuals then prepared the list of people to be interviewed. In all, 320 survey responses and 141 interviews were used to compile the results tabulated below.

Certain needs were found to be common among all types of institutions.

Distance education needs which were recognized as being common among all types of users are discussed in the following section. Additional, more specific requirements which were associated with the different types of institutions appear later in the report.

It is important to note that the tabulated survey responses presented in this document represent the distance education related needs and requirements **as perceived by the respondents themselves.** Although most persons surveyed had firmly held convictions with respect to some aspects of distance education, it is nevertheless true that solutions offered by a few of the interviewees may not employ the most flexible or cost-effective delivery methods available today. This portion of the document does not attempt to *evaluate* the stated needs but rather to present them in the same context they were presented to the interviewer or as they appeared on the questionnaire. Subsequent chapters of this study will evaluate the relationship between *perceived* needs and the needs as viewed by a knowledgeable outside consultant/observer.

Only a very small number of respondents indicated that they are not pursuing distance education solutions at the present time, because the need for it has not been demonstrated at their institution. The remainder of this document reflects the perspectives of the overwhelming majority who did indicate a desire to utilize distance education techniques.

2.2 Common Needs Among All Users

2.2.1 Staff Education, Awareness, and Planning

Of all the diverse needs specified by the distance education study participants, the ones heard most frequently were a desire for more technology system planning, such as inter-district and intra-district coordination, direction-setting, and general staff awareness with respect to distance education terms, technology, and capabilities. There is broad agreement that potential users of distance education, as well as those just getting started with the planning process, require guidance and support in matters of costs and migration strategies, as well as "where to begin" and "who to contact."

Awareness of distance education capabilities and system planning assistance were found to be prime requirements.

2.2.1.1 Planning Groups

Several people indicated that the establishment of local and/or statewide distance education planning groups would be useful in addressing the lack of expertise at the individual institution level. Such groups would also function as a support system for existing distance education efforts. Some of these existing programs are being conducted and maintained by a relatively small number of people, and are susceptible to being abandoned with the loss of as few as one faculty member.

Formation of regional planning groups was deemed important by users.

Users who are already involved in some distance education efforts believe their endeavors need to be coordinated with programs being planned for other regions of the state. Without statewide planning, potentially incompatible systems might frustrate future connectability.

Another aspect contributing to the desire for such planning groups is a general belief among many educators that the identification of specific outreach needs and the planning for future programming must be conducted **before** a commitment is made to a specific network technology, topology, or delivery method. They believed such planning should include institutional representatives with expertise in both the instructional and the technology areas. Such expertise is relatively rare and should be shared among institutions via planning groups.

2.2.1.2 Network Planning Priorities

Most users saw creation of a local network as the first priority; connection to other regions would be secondary.

Users have stated that the first priority of network planning initiatives should be to develop local networks connecting nearby schools based upon common interests and needs. This requires a design incorporating protocols and features which would be compatible with any future regional or statewide overlay network. The need to establish or maintain effective connection to other regional, state, and national educational video and data systems is seen as a secondary priority among those persons not presently using distance education systems. However, among persons presently using distance technologies, this same need for connectivity was generally ranked to be at least on an equal footing with the need for development of new systems.

Some institutions, especially smaller rural ones, believe that they need to develop their own course programming first, before accepting programming from an outside community. These schools believe that programming sources outside of their district may not fully understand the specific needs of their institutions. After local programming is operational, other network access might be more acceptable to them.

2.2.1.3 Staff Development

Using distance education systems for staff development and video teleconferencing is very desirable.

Respondents were nearly unanimous in the belief that using distance education technologies for staff development (inservice activities) will lead to important savings in administrative overhead as well as enhanced teacher professionalism. Examples of such programming include seminars on new teaching methods and courses such as asbestos recognition for school support staff.

Most persons expressing an opinion on the staff development aspect of distance education thought that the relatively low cost of production makes administrative teleconferencing and staff development the most important use of distance education technology. It is the opinion of these people that the nature of staff development and administrative formats would fit in well with the limited staff time available for program preparation.

2.2.2 Funding and Capital Cost Considerations

More than 85% of the persons responding to the mail survey identified lack of funds as either the first or second most important obstacle to the development of a distance education system. Grant proposal writing assistance was cited as a major need by more than 80% of the survey respondents.

The majority of respondents associated with even the smallest schools expressed interest in distance education. However, many have not undertaken programs solely because of a lack of funds. Even in cases where convincing demonstrations can be made that these technologies could save money in the long term, they are not being pursued because of the unavailability of money for up-front capital expenditures. In some cases, pressure on local school boards to reduce costs presents the primary challenge to the implementation of any new technology. These institutions believe they need help in the preparation of feasibility studies which could demonstrate to those allocating school funds that distance education systems could benefit students and save money at the same time.

Funding remains the main obstacle to creating new local networks.

Some users expressed apprehension concerning the continuing expense of distance education systems, especially the recurring costs of carrier access charges. At the present time, many respondents prefer to use available funds for planning, course development, and for facilities such as VCRs and studio equipment, which are independent from the actual transmission of programming. This opinion is by no means unanimous, however, and definite differences in approach to funding priorities is evident from the surveys. Most institutions expressed the opinion that they would prefer a video and data transport system which they could use on a "pay as you go" basis, much in the manner of today's telephone system.

Users would welcome assistance in grant writing and in funding feasibility studies.

The consensus of the respondents was that additional money for planning and pilot programs is required. One possible source for such funding is grants. Respondents strongly indicated that they would appreciate state assistance in obtaining such grants.

2.2.3 Relevant Technology

Most users, especially the low volume users, believe they are better served by purchasing video, data and voice transportation on a *demand* basis which consists of two components:

- Access on demand.
- Bandwidth (i.e. capacity) on demand.

Users would prefer to pay for network services on a usage basis rather than a flat recurring fee.

This capability reflects the ideal system whereby connection to and the capacity of the network can be changed dynamically based on the requirements of users. For instance, if additional teleconference quality video is required, the necessary additional channel capability could be added and paid for only as long as the teleconference is in session, much as long distance telephone traffic is paid for today. Similarly, computer users would like to use data transfer rates which would allow them to compromise between delivery times and the cost of the necessary bandwidth. This technique of allowing users to pay for network transportation as it is used has the advantage that no users would be paying for dedicated resources that are idle. This capability is called *video dial tone*.

Most of the respondents who could be categorized as "technically sophisticated" stated that buying network resources on such a demand bandwidth basis was crucial, in spite of today's limited availability of such services. These users generally believed that "switched" high bandwidth services will be available sooner than the estimates of 10 to 15 years supplied by some vendors.

A small but significant percentage of persons contacted stated that they have already determined which technology or procedure is appropriate for them, and outside suggestions involving other techniques are not being sought.

2.2.4 Role Of A Statewide Network

A statewide distance education plan should include the establishment of standards.

Most persons interviewed believed that the creation of overall standards which will facilitate interconnection of regional networks (thereby creating a statewide network) was a laudable goal for the future. There was also a consensus that funding should not be based upon a requirement to use any one particular technology or to buy bandwidth from any one particular entity. Any such requirement would, in the opinion of many persons, result in a lack of acceptance of such a statewide plan.

It is felt that local users must remain free to choose their level of participation in state activities and to retain control of their local systems.

Nearly all respondents were unanimous in the belief that use of any statewide overlay network should be optional, that individual institutions should be free to pursue other opportunities, and that no agency or committee should act as a "gatekeeper" for system access. This preference confirms a similar conclusion reached in another recent study conducted by the State of Wisconsin. There was also nearly universal agreement that any such network should be easy to use, should have a well-defined migration path from the regional technologies currently being employed, and should not place excessive cost or procedural burdens upon the users.

Several persons contacted offered the opinion that user groups should have the maximum degree of access to the scheduling functions on both their regional and any recommended statewide network. Although many operating systems (for instance, several of the ITFS networks) currently employ such user groups, a few of the institutions contacted believe they are underrepresented on these committees. On the other hand, several users ventured the opinion that access would not be a problem provided that new systems were properly designed for migration and expansion.

2.2.5 State Assistance And Incentives

The following needs relating to state assistance and incentives were evident from the surveys and interviews:

- More then 75% of survey respondents indicated that technical assistance from the state to local districts is needed.
- Lack of time to develop distance education systems, as well as a scarcity of trained personnel, were frequently cited by respondents as obstacles to the development of distance education systems. To a large extent, this is a financial issue that reflects the ability to hire local staff.
- Over 88% of the persons surveyed by mail believed the state could be of some assistance in providing planning resources, technical information, grant preparation assistance, and direct funding.
- The inability to recruit staff experienced in distance education was cited as the number one or number two implementation obstacle by approximately half of the respondents.
- According to most institutions surveyed, the state should promote distance education techniques by creating a mechanism that will provide assistance and financial incentives to educators who develop unique solutions to needs and applications which relate to technology that can enhance the mission of educational institutions throughout the state.

Local users require access to technical expertise independent from vendors. Many would appreciate such assistance from the state.

Most users believe that the state should provide financial incentives in order to promote distance education.

2.2.5.1 Technology Resource

Many institutions expressed the need to obtain access to a technical resource, through which they could secure answers to specific questions and get updates and information on evolving technologies. Currently, one of the primary methods of obtaining such information is from equipment vendors. A technical resource person, however, could assist in the resolution of problems and questions across the entire distance education spectrum without any bias towards one technology or another. Currently, unanswered technology questions have a tendency to impede the progress of system planning. It was thought that the state could be the resource for establishing such a service.

2.2.6 Outreach

A majority of post-secondary school respondents identified four specific educational instructional needs they are trying to satisfy through use of distance education systems:

Users want to employ distance education systems to reduce student / instructor travel, expand course offerings, reach non-traditional students, access more resources, and equalize educational opportunities.

- Reduce instructor travel time and associated staff expenses incurred while traveling to locations where courses are to be given to assembled student groups.
- Reduce student travel time incurred while traveling to locations where college level and continuing education courses are to be given.
- Expand credit courses offered at the institution in a cost-effective manner.
- Reach non-traditional students (e.g. homebound, incarcerated, or on-the-job) whose ability to appear on campus at specific times may be limited.

In addition to the above instructional needs, most persons specified the following non-instructional needs for which distance education technologies could offer a solution. These requirements, unlike those above, are not specific to post-secondary schools, but rather reflect the needs of virtually all respondents:

- Communicate with other institutions for administrative purposes, such as staff meetings.
- Exchange resources such as video course tapes and data files.
- Provide staff with in-service professional development opportunities at times which are more accessible for them.

Those institutions presently using distance education systems have identified the need to expand their networks and to interconnect with other systems.

A variety of distance education systems have already been established in many areas of the state, and several more are in the planning stages. Users who are involved in these efforts have begun to identify needs beyond those associated with the initial creation of these systems. These needs are categorized as follows:

- Expand the system so as to reach greater numbers and more categories of end users.
- Provide teacher certification courses.
- Create business and industry employee programs to improve productivity and provide professional development.
- Tie together similar distance education entities and networks throughout the state.
- Access more sophisticated networks and databases.
- Incorporate increased access to government agencies on the system.

2.2.7 Professional Development and Staff Development

Networks could also be used for professional development and administrative purposes.

The need for professional development and other inservice telecourses was frequently mentioned by all categories of educational institutions, and by such state agencies as the Department of Public Instruction. For purposes of this discussion, "Professional Development" will be defined as continuing education required to maintain or expand certification or degree requirements of existing staff, or to qualify for higher pay scales. "Staff Development" is defined as those programs which enhance personal skills, such as time management, job-related awareness, and interpersonal communication techniques. To refer to either or both concepts, the term "inservice" will be used.

As previously mentioned, many respondents were of the opinion that the use of two-way interactive video technology for staff development involves lower production costs and shorter planning cycles than instructional telecourses. They believed that such programming could be implemented relatively quickly. Some users stated that implementation of a distance education system could be justified on the basis of staff development alone. Once such a system was in place, however, many people also believed it would be used for administrative meetings and, ultimately, for instruction.

2.2.8 Other General Considerations

2.2.8.1 Curriculum Coordination

Although not a specific part of this study, throughout the needs analysis process it became apparent that there is a fundamental need for regional curriculum coordination. This need will become more acute as new local distance education systems are created. There is currently an overlap of courses and programs which are being offered by different institutions serving the same categories of students, and even the same geographic area of the state. Many respondents believed that reducing this duplication of effort and focusing instead on the program needs of a wider area would be a more efficient use of resources. This coordination would also help to establish mechanisms to serve the program needs of special students (such as Gifted & Talented and Cognitively Disabled classes), as well as special interest programs in advanced subjects which may have relatively few subscribers in any one school district (e.g. Advanced Placement courses).

The study identified a need for coordinating curricula in a region, especially for specialty programs.

2.2.8.2 Scheduling Coordination

During the planning process for a distance education system, many potential users expressed the need for coordination among other potential users in scheduling electronic classes so that existing schedules are minimally disrupted. Schools operate on different schedules and calendars, and most were reluctant to commit to a system which would impose another scheduling constraint, or which would result in their students missing some classes.

Different school schedules and calendars create challenges in scheduling electronic classes.

According to these educators, the scheduling process is already difficult due to staff shortages, the needs of non-traditional students, and non-simultaneous vacations. Many of these institutions indicated that, without an appropriate degree of flexibility, they would prefer to continue using videotape-based courses rather than switch to live interactive classrooms.

In order to resolve such conflicts, many people recommended that the previously described user groups could determine when and how often the telecourses should be made available on various systems. Ideally, according to a minority of respondents, a "pay per view" system would be appropriate for courses not requiring interactivity. These courses could be selected from an item menu on short notice, and would use technology which employed an audience targeting capability not appropriate for broadcast media.

For interactive courses, a suitable amount of flexibility, as well as a workable number of telecourse repeats, would be incorporated by the user groups. It should be noted that this last scheduling problem is similar to that now faced by the UW-Extension, which rotates some courses through a one or two year repeat cycle.

2.2.8.3 Scheduling Occasional Use

Some active as well as potential participants in distance education systems have experienced difficulty in placing occasional and non-recurring programs on existing regional networks. This is especially true for courses or programs that occur on a spontaneous basis, and the problem was most prevalent among some institutions of higher education and K-12s who do not produce significant amounts of program material. The following example, heard from one institution, details the need to address the occasional use scenario:

Frequently, users on existing networks have trouble finding available network time for one-time or last-minute programs (such as a video teleconference).

Frequently, the institution requesting occasional use is told by those who control the local distribution network that expensive equipment will have to be purchased, such as transmitters and antennas, in order for the requesting institution to use the network at all. The requesting institution is then left to wonder whether these distribution facilities, at least some of which may have been built partly via state funds, are being properly utilized. The controlling entities, on the other hand, have a substantial investment in the system, and they believe it is not appropriate to preempt their own programming in favor of that from institutions which should have indicated an interest in the system during the planning process.

It is expected that the occasional use problem will only become more severe as distance education systems proliferate. Experience shows that more uses can be found for a functioning distance education network than can be imagined for one which exists only conceptually. In addition, an increasing number of one time programs such as staff development teleconferences are being offered by the UW extension and by other services. This occasional use requirement is another reason why there is a need for demand bandwidth, as defined earlier.

Occasional network users would prefer not to invest large amounts of money in seldom-used equipment.

2.3 Additional Needs of State Institutions

This section identifies needs not specifically discussed in the general section above which are unique to each type of institution.

More specific needs were found among each type of institution.

2.3.1 VTAE Institutions

2.3.1.1 Expanded Student Pool

Most VTAE institutions are extremely interested in outreach as a means of expanding their student base, especially to include K-12, the Veterans Administration (VA), industry and various medical contacts (see Section 2.3.1.2 below). In fact, the state is now considering a mandate that high school students have access to Technical Preparation courses if they do not intend to continue on to a four-year college. Such a mandate is viewed as an opportunity to further these efforts.

The VTAE schools want to reach out to new students, including K-12s, medical facilities, and private businesses.

Most of the state's VTAE schools already rely upon distance education in order to adequately cover the large geographic areas for which they are responsible. The size of these areas often dictate using distance education as a more cost effective method for program delivery. Several VTAEs also mentioned that expanding the student base in this way would also bring in new revenue through additional tuition.

2.3.1.2 Business And Medical Connection

Many VTAEs expressed a need to enhance working relationships with the business and medical communities. This would require a thorough survey of the business and medical establishments in order to determine the extent to which they would benefit from a statewide distance education network. If such private sector benefits could be shown, the use of a potential statewide overlay network by both businesses and educational institutions would be a possibility which should be addressed in the future. In the interim, and as models for the future, VTAEs such as Milwaukee Area Technical College are providing programs to workplace learning centers and are experimenting with innovative concepts such as paperless courses. These efforts are expected to expand when dial-up access to digital bandwidth (DS-0 and DS-1 circuits) is available to local subscribers.

2.3.1.3 Intra And Inter Institution Traffic

Many technical schools expressed a need to deliver expanded video course programming to district regional learning centers and remote campuses, as well as to share resources with other VTAE institutions. For example, Madison Area Technical College desires to reach Blackhawk Technical College in Janesville as an outlet for their Dental Hygiene Program. Resource sharing could include the exchange of course materials, documents, testing, and homework evaluation via high-speed electronic means, such as Group 4 (fast 56 kilobits per second) FAX machines and computer graphics terminals. A reduction in staff overtime and travel costs, while simultaneously expanding student opportunities, are seen as the primary benefits of this delivery capability.

The VTAEs expressed strong interest in interconnection with each other for both instructional and administrative applications.

Several schools expressed the desire to employ a statewide administrative and instructional network for voice, video, and data exchange among all Wisconsin VTAE campuses. Such a network would address needed curriculum expansion, curriculum sharing, and staff development. Many VTAEs have expressed a desire to offer more distance education courses, but are currently constrained because of budgetary considerations, lack of capacity on existing systems, and a lack of trained personnel.

Most if not all of the Wisconsin VTAE institutions contacted have investigated the possibility of using existing regional distance education systems to serve their geographic areas, or to reach new students. Many times, such potential uses are frustrated by the lack of connectivity between systems. In a few cases, lack of links covering as little as 80 miles prevent interconnection. The following scenario illustrates this point:

Northcentral Technical College in Wausau would like to interconnect its ITFS and microwave system with the ITFS system at Chilton which could also be used by Fox Valley Technical College to mutual benefit. In addition, the ERVING fiber optic project in Clintonville would gain new outlets at the same time, merely by constructing a link to cover the portions of the Wittenberg/Clintonville/Appleton backbone not currently served by fiber optic cable.

Once this interconnect system is in place, use by several other institutions, such as UWM in Milwaukee, and the Milwaukee Area Technical College, could be added with relatively minor additional effort. This would allow the sharing of engineering and medical programs, as well as enable prisoner education at Oshkosh Correctional Institute and Green Bay Correctional Institute. Ultimately, the extensive Green Bay ITFS system, which serves a vast K-12 population, could be added, as well as the ITFS network used by Lakeshore Technical College at

Cleveland. Even the 16 channel Milwaukee Area Instructional Network could be ultimately appended. If these system interfaces are designed correctly, a virtual backbone is formed.

Of course this is merely one of several possible scenarios. Some respondents expressed the opinion that appropriate funding and planning is the sole prerequisite standing in the way of the implementation of distance education technologies.

2.3.2 CESA Institutions

Several Cooperative Educational Service Agency (CESA) offices expressed a desire for electronic interchange with other CESA offices for video, voice, and data. As a first step, most districts desire to be connected to selected neighboring CESAs. For instance, CESAs #10, #11, and #12 have expressed interest in establishing a "regional cooperative" for purposes of data and video interchange.

The needs of CESAs include the interconnection of CESA offices and districts for administrative uses. Also, it is envisioned that a network could be used for distance education instructor training and for the sharing of student educational programs.

A statewide backbone providing interconnection capabilities between all CESAs and the major school districts is seen as a future goal. In addition, access to some outside media services would be desirable. For instance, CESA #1 no longer maintains a media library; however, an extensive library is available from a private company which is in the process of planning for electronic access to its film and video materials. It is thought that such a network would address both inservice and administrative requirements, such as electronic mail ("E-mail") and delivery of video library materials. The principal benefit of such a system would be the reduction in staff travel time and cost which is currently a result of inter-district and inter-agency meetings.

In addition to a statewide network connection, one CESA expressed a desire for access to national and international two-way interactive video programming.

Some CESAs are establishing extensive distance education networks in their jurisdictional service areas. The initial goal of these systems is to economically expand curriculums at K-12 institutions, especially high schools. Programs for the gifted and talented, advanced placement students, and other specialties previously available only at a few schools are being created for areas with low student populations. Continued financial and technical support is requested for these efforts.

Training and continuing education for distance education instructors is a constant need among these CESAs. Since many of the distance education teachers live in some of the most remote regions of the state, it is especially difficult for them to enroll in continuing education courses without traveling an inconvenient distance to the source of instruction.

One of the most important concerns of those currently operating distance education systems is the assurance that any proposed State Overlay Network be designed to be compatible with their existing systems, and that it not place additional demands upon them without offsetting funding.

2.3.3 K-12 Institutions

The prime K-12 need is the statewide equalization of students' learning opportunities.

Most K-12 districts and institutions believe that distance education systems will enable the equalization of learning opportunities for students statewide, thereby achieving a more equitable allocation of educational resources. Existing programs such as SERC (Satellite Educational Resources Consortium) have acquainted local staff with the advantages of distance education, but will not provide the complete solution for the future because of a lack of inter-activity.

Individuals at K-12 institutions identified the need to use distance education technology as a mechanism for instructors to maintain their certifications. At present, many K-12 instructors do not have ready access to continuing education; consequently, the credential process is delayed or made much less convenient because it can only be done during the summer.

Improved teacher training and the timely sharing of student records are also important K-12 needs.

A need was also identified for professional development programming that would enable teachers to pursue graduate level courses and Ph.D. programs in areas such as educational administration, science, and math. Also, inservice seminars need to be conducted at times which dovetail with teaching responsibilities.

Another expressed need unique to K-12 districts is the ability to access a student's records as they migrate through the K-12 system. Access to student records will also ensure the school district is meeting state educational mandates. This tracking requirement will become particularly important as the DPI develops the Report Card Project. This project will track student statistics with respect to graduation rates, dropout rates, and student/teacher ratios. These data bases might include such data as grades, schools/years attended, and other pertinent information which would require multi-point access. This information could be used for research and statistical purposes, and would be critical to making timely educational decisions for the students. Currently, the time that is required to collect this same information is seen as a hinderance, especially since the data turnaround time at the state level is approximately one year long. By the time the school receives the feedback from the state, the information is outdated.

Many K-12s, CESAs, and DPI officials believe that a major need with respect to data networking is statewide access to the UW's WISCNET computer data network. Such access would provide connectivity to library data, the Internet network, and Electronic Mail.

More than most other types of institutions contacted, K-12 schools expressed the need for high levels of technical assistance and support in the use of distance education and other technical equipment. Planning for future distance education systems is frequently thwarted due either to the absence of a technical resource, or to the lack of a person to act as an expeditor. An expeditor would be able to coordinate needs with the appropriate technology, and explain costs and other ramifications in simple, understandable language. More efficient access to existing agencies which provide assistance in technical matters, such as the DPI computer library, may lessen the extent of this problem.

K-12s desire access to the WISCNET computer network.

The Department of Public Instruction expressed the need for a mechanism to interact with schools on a real time basis in order to clarify such issues as distance education teacher certification requirements. In several instances, this was identified as a good subject for an interactive teleconference.

Many K-12s require technical assistance to set up or operate a local network.

2.3.4 University Of Wisconsin

2.3.4.1 4-Year Campuses

There is a general belief at many campuses that a need exists for financial and planning assistance in developing distance education programming. Specifically, the faculty should be provided with additional time and other resources to create and produce distance education programs and courses.

Among the UW 4-year campuses, needs include planning assistance, increased system capability awareness, and expanding degree program availability.

Many campus distance education and media representatives indicated the need for an increased level of awareness on the part of their faculty. They are most interested in exposing the faculty to the capabilities of distance education, so they will become more interested in developing programs.

Several program needs were also mentioned by some of the universities. For instance, there are no University-level engineering degree programs available to Wisconsin residents north of Madison and Milwaukee.

Since the UW doctoral and comprehensive campuses are sites of major research projects, there exists an important need to improve electronic access to state, national and international voice/video/data computing resources and databases. In addition, connectivity to national interactive video teleconferences and access to individual colleagues at other institutions is becoming a necessity for faculty and staff enrichment. With this increased connectivity, however, should come increased reliability; one 4-year school expressed reservations concerning the fact that all high data rate computer (DS-1) traffic was being routed through Madison, and desired to have alternate routing in case of failure.

Faculty need access to resources which assist research and enrichment.

As might be expected, opinions differed concerning the appropriate role of the state government in developing a statewide overlay system. They ranged from institutions which expressed the majority opinion that the state should take a leadership role in this effort, to one institution that believed the state should not have any role in this process. On the other hand, this same one institution was of the opinion the state

Opinions at UW differed on the role the state should play in network creation.

should use its influence to help telecommunications providers understand the critical importance of making demand bandwidth available to educational institutions as soon as possible.

2.3.4.2 UW Centers (2-Year Campuses)

Some UW Center needs have been addressed by the Centersnet computer network.

Virtually all of the UW Centers indicated a very positive response to the creation of the CentersNet data network. CentersNet allows data and Electronic Mail exchange between the 2-year and 4-year campuses, and access to other national data networks via the Internet gateway. For some of the Centers, this system substantially meets their current needs. A minority of persons interviewed, however, expressed the opinion that access to CentersNet should be provided at higher data rates.

Many Centers would like a comparable two-way video system to share instructional resources throughout the UW system.

Other respondents expressed a strong desire to use an arrangement similar to CentersNet for video, so that credit courses could be shared among the Centers and so that the substantial travel time for meetings could be eliminated. The need for video teleconferencing is especially significant at the Centers, given their unique organizational structure. As an example, chemistry is taught at all 13 Centers; unlike the 4-year campuses with individual Chemistry departments, the Centers have a single Chemistry department which encompasses and serves all campuses. All the faculty in this department must meet several times a year, while the deans meet approximately once per month as a group on selected campuses around the state.

An additional benefit of the video interconnect, according to a majority of the Centers, would be access to the 4-year campuses for 2-way course programming and sharing.

Providing courses to high schools and businesses is important.

Some of the Centers have received numerous requests from people within their communities to provide both graduate and undergraduate courses to local high schools, as well as to business and industry. UW Centers have not been as aggressive in pursuing these outlets as have the VTAE institutions. However, there is a growing awareness by the Centers that such connections will be required as the public becomes more cognizant of the educational opportunities technology brings and begins to request expanded accessibility to these institutions.

2.3.4.3 UW-Extension

A significant portion of the UW-Extension respondents believe that their most important need is in the area of planning and funding. Extensive planning is needed within the UW-Extension to coordinate the various projects/technologies currently in use and to eliminate duplication of effort.

UW-Extension hosts numerous professional development courses at various locations around the state. Continuing education credit is granted for these courses. A method is needed to make the lectures for these courses more accessible to a greater number of people, perhaps by use of distance education technologies. As a side issue, one Extension representative raised the issue of copyright. At the present time, no standard formula exists to compensate the lecturers in the distance education environment, and to protect them from unauthorized duplication.

UW-Extension needs include planning and funding assistance, program underwriting, and the increased availability of continuing education courses.

The Extension has a great deal of programming for which it requires underwriting in order to begin production. This funding would include money for production costs, production equipment, maintenance equipment and personnel, instructors, coordinators, technicians, administrators, and other human resources. Funds would also be required for instructor and user training.

2.3.5 Independent Colleges and Universities

The independent colleges and universities interviewed mentioned many of the same needs as the state-supported 4-year institutions. Limited human and financial resources to meet their identified needs was a major concern.

Because of more limited funding, independents tend to be less far along in distance education planning. Involvement in local planning groups is important.

According to the survey data, the independent institutions, more than other groups, require education and assistance in acquainting their staff with distance education capabilities, applications, technologies, and costs. They also expressed the desire to be more involved with existing planning and user groups, and other such planning groups as might be established for purposes of planning a distance education infrastructure.

Because state funds tend to be less available to independent schools, these institutions have made less progress in creating distance education systems. Consequently, there is some fear that they will be bypassed when the video/data highway does come.

Some of the independent colleges expressed a desire to be connected to WISCNET.

Another need expressed by several of the independent institutions was for the capability to conduct video teleconferencing to reduce travel expenses.

2.3.6 Libraries

Many libraries' needs relate to computer data: access to catalogs,documents , and databases.

Most of the libraries which responded to the distance education study survey are already using the CD-ROM-based WisCat system for catalog sharing. Many of these same institutions see a need for catalog and document abstract information to be available on-line to their subscribers. Currently, document exchange is a manual, mail-based process, although some use of the FAX machine is evident. Open access to electronic catalog and abstract files would free library staff for other tasks and improve response time for end users.

Libraries responding to the survey frequently mentioned that they would like to be connected to WISCNET/Internet for electronic access to other institutions.

Another need, especially expressed by the DPI library, relates to non-electronic databases. Currently, microfiche, books, and other hard-copy records represent the majority of library resources. For distance access systems to be effectively utilized, a massive effort would be required to convert these databases into electronic form (c.f. the Gutenberg Project). There is some understandable reluctance to begin this work in the absence of a delivery system. In the meantime, it frequently can take two weeks for requested documents to be delivered; this process frequently involves relatively high copying costs as well.

Libraries are reluctant to convert hardcopy databases to electronic form without an existing delivery system.

The current electronic transfer of information among libraries is intended for use by both the library staff and library users. These existing networks tend to be local or small regional efforts utilizing dial-up analog telephone services.

In the area of professional development, a number of administrators mentioned a desire to obtain courses and seminars from the Library School at UW-Madison.

One respondent stated that libraries needed to be more aware of what programs are being taught in the high schools. This would help them anticipate what materials they might be asked to provide before book buying decisions are made.

Librarians would also like to videotape public domain programs of general interest, and make them available to library users.

2.3.7 Government

The most frequently mentioned need by government agencies was the requirement for a video teleconferencing network to reduce travel time associated with meetings and training. Most respondents indicated they would like this network to be available on a demand basis in order to avoid the necessity of monthly lease payments for a system which might initially be idle a good portion of the time.

Video teleconferencing would reduce government travel costs and allow more employee training to take place.

Coincident with the teleconferencing need is a requirement for an extensive training network, whereby remotely located staff could receive programs to improve their skills or maintain certification. An example of this continuing certification requirement is the eye-coordination intoxication test administered by the Department of Natural Resources wardens. Wardens are stationed at widely scattered sites throughout Wisconsin, numbering approximately two wardens per county. A means of delivering video for training and administrative meetings to these wardens would enhance their professional development without taking time from other duties (especially during the busy fire season).

Some government entities indicated that they are currently doing without important staff training because of the travel costs involved in obtaining the training (which is often only available in certain locations such as Madison or Fort McCoy).

Access to several types of computer databases is desired.

City governments would like access to the Library of Congress, as well as federal legislative data and newsletters. Similarly, state agencies such as DPI would find it useful to have electronic access to national legislative databases so that computer filters could flag important pending legislation. At present, an enormous number of hours are required merely to review hard copies of governmental regulations. As a result, comments to pending regulations frequently cannot be made quickly enough to have an effective impact.

While several agencies desire access to federal databases, others require access to databases maintained by other agencies. For example, several agency requests for access to information maintained in the Department of Transportation (DOT) computers were documented. As is the case with libraries, many of these databases, such as some of these same DOT records, are not yet computerized. Therefore the construction of a computer data network would establish the need to computerize a great deal of information, bringing with it profound cost implications.

For some state agencies, access to a video conferencing network would dramatically reduce recurring costs, and would assist in the pursuit of their mission. The most vivid example of this situation is the state Department of Corrections, which would use a video system to replace the costly movement of individuals for routine court appearances. Many county judges have ruled that video appearances are an acceptable alternative to in-person proceedings.

Certain agencies within state government have an immediate and extensive need for distance education technologies. For example, the Department of Corrections and the State Patrol indicated that they both would be relatively heavy users of an interactive distance education system. This system would be used for both staff development programming and for training purposes. In addition, regular educational programming could be provided to the inmates at the maximum security institutions, eliminating the need for instructors to travel to the institution.

The Department of Corrections also expressed a need for a data network which could be used to access medical and other data records.

2.4 Needs Of Installed Networks

Existing local networks would like to obtain more programming and would like to interconnect with other nearby networks.

The following needs were identified with respect to existing video distribution systems in Wisconsin:

2.4.1 Existing ITFS Networks and Other Projects

Most of the state ITFS systems requested access to narrowcast programs similar to that available on Madison's WHA cable channel 3, which many respondents view as the beginning of a second educational television network. Some of these systems have pursued interconnection via cable TV systems, but in general, other methods are preferred for reasons of reliability.

Most of the existing ITFS systems would also like to interconnect with distance education projects in adjacent districts. There has been some concern over how to design these interfaces in a cost effective manner, however, and some confusion over which entity would own the required equipment. For instance, many additional video channels could be carried by the Trempealeau County Community Antenna Relay Service (CARS) band microwave system, as well as the Northcentral Technical College FM microwave system. However, the respective frequencies could only be assigned to the current licensee.

In addition, studio links would have to be built, involving uncertainties associated with federal agencies such as the FAA and FCC. Some other systems which *could* be used for the transportation of compressed video, such as the State Patrol microwave network, are maintained by segregated state funds (i.e. the funds can only be used for this network's maintenance). Assigning the proportionate share of the system costs may therefore be somewhat difficult, especially if the new educational users become the major consumers of bandwidth.

Because of the factors discussed in the preceding paragraph, many existing system users have a need for a higher level of technical and regulatory awareness than individual institutions generally require in their local technical personnel.

As an example of a need which threatens the completion of some startup networks already in the construction planning phase, a few systems, such as the Indianhead Technical College ITFS project, are experiencing a need for additional funding resources due to cutbacks at the K-12 level.

2.4.2 WECB TV and FM Interconnect System

The existing WECB Wisconsin Public Radio TV and FM interconnect contract with MRC Telecommunications will expire in 1994. Presently, the WECB pays for transportation on a "services" basis. Therefore, an extra cost is assessed for each new audio or video signal which must be carried on the network, irrespective of the availability of new bandwidth conserving technologies. The need therefore exists to add new video and audio services in a cost effective manner, both on a permanent and on an occasional basis. One problem being experienced with the existing carrier is that lower costs are offered for new services only if the time period terms of the main contract are extended.

The need exists to deliver the TV and FM network to the existing sites from Madison, and to deliver programs from the production studios in Green Bay, Stout, and Milwaukee back to Madison in a more flexible, cost efficient basis. It is further desired to pursue digital transmission technologies.

As the current contract for the ECB TV and FM interconnect expires, a more flexible pricing structure is required for the future.

2.5 Validation Of Identified Needs

In order to ensure that the needs identified above were a true and accurate reflection of the respondents beliefs, several validation measures were taken during the project:

- A presentation and discussion session was conducted with the VTAE Media Consortium group, representing all VTAE districts. Representatives from UW-Extension and WECB were also present.
- A presentation and discussion session with the UW Educational Media Council was conducted.
- Several discussions were held with the WECB's Distance Education Technologies Initiative Committee and other WECB personnel.
- A discussion session was held with a group of K-12 Media Administrators.
- A copy of the "needs assessment" portion of this document was given to all those who either returned a survey or who were interviewed.
- Representatives from each major institution and organization participating in this study reviewed and commented on this document before its release.

After the needs were identified, they were discussed with the affected groups to ensure their validity.

2.6 Determination of Technologies To Meet Needs

As a result of tabulating and analyzing the requirements of all entities responding to this *Distance Education Technology Needs Assessment*, it is the conclusion of Evans Associates that a primary need has been demonstrated for a state role in the future planning, implementation, and support of both regional and statewide video and data networks to be used by educational institutions and government agencies.

It is concluded that a substantial need exists for a state role in the creation of regional and statewide distance education systems.

The next chapter examines the alternatives for meeting the identified needs.

The next chapter of this document will investigate alternative methods for employing cost-effective solutions to be used in meeting the above described needs. Additional system requirements based upon needs derived from expert analysis of the current Wisconsin environment will be identified. Migration from the existing environment to an appropriate mixture of delivery technologies will be described, consistent with the requirement that the user impact be held to a minimum. As part of this migration, several methods will be investigated for creating a partial or complete wideband State Overlay Network system which could be installed within the year 2005 planning horizon.

3. Technical & Financial Implications

3.0.1 Abstract

This chapter examines the technologies available to meet the identified needs.

This chapter of the document will examine some of the issues, advantages and disadvantages associated with using alternative technologies and various network topologies configured to meet the distance education requirements identified in the previous *Needs Assessment* chapter. Included is a summary of how other states have approached these same choices, and what conclusions can be reached from these experiences which are relevant to Wisconsin.

In the discussion which follows, certain technologies and configurations will be explored in depth while others will not be considered for a detailed analysis because of unrecoverable fiscal or migrational shortcomings. Those technologies not meeting the cut-off criteria for cost-effectiveness will be identified and the reasons for the unsuitability explained. Finally, a summary description of the recommended technology mix will be presented as a solution to the demonstrated need for a distance education network in Wisconsin.

The information presented in this chapter will provide a foundation for the network design, implementation plan and migration strategy to be presented in subsequent chapters of this document.

3.0.2 Network Configuration Components

The alternative statewide distance education networks to be explored consist of three basic components:

- The Overlay Network, or *Transportation System* (Tier 1).
- The Regional Network, or *Distribution System* (Tier 2).
- The Local Network, or *Local Loop* (Tier 3).

The technologies are evaluated in terms of their applicability in three areas - the overlay network, regional networks, and local networks.

Each of these basic elements becomes successively more dedicated to a localized group of users, and therefore may require differing levels of state support. At the same time, each element requires interface with a distinct mix of service provider categories. For instance, primary responsibility for acquisition and contract manage-

Emphasis is placed on the overlay network, as regional and local networks are best left to the control of local users and groups.

ment of the overlay transportation system would most logically rest with a system integrator such as the State of Wisconsin Department of Administration's Bureau of Information Technology Management (DOA/BITM), the state agency already familiar with the management of similar networks.[1]. The overlay transportation system (dubbed WODIE) could effectively employ inter-exchange carriers, unregulated long distance carriers, and private microwave facilities as components.[2] Under BITM's stewardship, the new wideband services required by distance education could be aggregated with existing routes in order to reduce duplication of transportation capacity.

At the local level, primary responsibility for video and data *Tier 3* "tail circuits" would logically fall to the individual schools, businesses or institutions working in conjunction with the local exchange carriers (LECs) and/or cable TV operators. Regional Networks may well be managed by consortia, CESAs, or other cooperatives involving a mixture of jurisdictions.

As the design of these networks is contemplated, it is important to remember that the historical role of the State of Wisconsin with respect to educational technologies has been to provide the *conduit*, while the *content* is controlled by the users. This dichotomy provides a natural separation between the network management and traffic functions, so that the provider of services is not also the gatekeeper. Such a natural division has served all parties well as the existing WECB ITFS system has been built and has matured over the last ten years. At the same time, and in accordance with WECB's mission, it is envisioned that the

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[1] DOA/BITM currently manages the state telephone system (STS), the computer data network (CDN), and the lottery network

[2] For transportation between nodes within a LATA, Local Exchange Carriers could also be used.

WECB would continue to disseminate technical information and provide grant application and planning assistance to local and regional distance education groups. Subsequent chapters in this document will introduce the concept of a *system integrator* role for the WECB, whereby network management functions such as the coordination of centralized leasing and the direction of technical maintenance would be enabled.

3.0.3 Video Resolution Terminology

Video needs usually determine the needed capacity of a network. Depending on picture quality, five different levels of video are possible.

At the local and regional levels, video applications consume by far the largest portion of electronic transportation capability. Video requirements therefore most frequently drive system bandwidth design.[1]

According to the *Needs Assessment*, video signals destined for significantly different purposes will be carried on the ultimately designed Wisconsin overlay network. Some of these disparate uses imply profoundly different resolution requirements.[2] The following terminology will be used for the purposes of this document to refer to the various resolution levels required by different applications:

- *Level 1 or High-Definition TV*: Horizontal, vertical and time resolution compatible with the FCC's emerging HDTV standards, for use in home theater or medical applications. At present, this resolution level can only be achieved by fiber or coaxial cable employing at least 90 Mbs (2 DS-3).

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[1] Supercomputer data transfer rates can equal or in some cases even exceed bandwidths required for full motion NTSC video. However, supercomputer requirements can be easily accommodated on networks which employ standard video capacity increments such as OC-3s and OC-12s (Optical Channel equivalents of DS-x channels.

[2] Terms such as video "quality" as applied to one application or another should be used with care, since this expression implies that some pictures being viewed are in some manner inferior to others. Just as a cup cannot be filled with more liquid than required to reach the brim, video resolution must be "sized" to fit the task at hand. For instance, a broadcast television station typically must tape or rebroadcast a program several times before it reaches the end user, thereby requiring a higher initial video standard in order to equal the noise-free final product as delivered by closed circuit applications. As a further factor, two different video signals may meet the standards set by the *National Television Standards Committee (NTSC)*, yet differ by the amount of compression employed (time domain resolution). Higher rates of compression (which require less bandwidth) may be appropriate for a "talking heads" video teleconference, but not for a basketball game, because the action may be "blurred" or "jerky".

- *Level 2 or Broadcast TV*: Resolution compatible with usage by today's network television delivery system, for use in demanding educational applications requiring full NTSC and EIA motion standards. This resolution level can be reached by most backbone transportation technologies at the full ("high-cap" 45 Mbs) DS-3 level.
- *Level 3 or Credit-Course TV*: Resolution compatible with delivery by today's analog cable television systems or by the AM analog microwave technology utilized by Instructional Television Fixed Stations (ITFS). This resolution level is used for instructional programming requiring the maximum flexibility and rapidity of motion, and is consistent with 34 Mbs or 36 Mbs digital codecs.[1]
- *Level 4 or Staff Development TV*: Resolution compatible with delivery technologies such as Cable TV, fiber, microwave and ITFS whereby two video programs are multiplexed on one traditional broadcast TV channel. For instance, analog transmission employing alternate frame multiplexing is consistent with the Level 4 mode.[2] This resolution level is also referred to as "entertainment quality" (for instance, the picture delivered by the AT&T Telstar 401 satellite using 1/8 transponder corresponds to Level 4 resolution at the present state of codec development).
- *Level 5 or Video Teleconference TV*: Resolution compatible with delivery by a single DS-1 digital circuit for use in long-distance meetings and planning sessions.[3]

This section explains and evaluates the alternative technologies.

3.1 Identification of Technology Alternatives

The purpose of this section is to identify those technology alternatives which are appropriate for each of the basic components of a statewide distance education system. After the considered technologies are presented and analyzed, the advantages and disadvantages of each technology will be explored, along with

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1. Both 34 Mbs and 36 Mbs coexist as standards depending upon the codec manufacturer. For the purposes of this document, these two data rates will be considered to be functionally equivalent, and the higher rate will be used in capacity calculations.
2. Video multiplexing is carried out at the baseband level, which means that no changes are required to codecs or fiber capacity in order to increase the number of video signals carried from one to two.
3. For some "talking heads" applications requiring restricted motion, even lower rates may be employed (down to approximately 128 Kbs). It should be remembered that even at the lower rates it is possible to achieve highly detailed pictures merely by reducing the screen "refresh" rate, and sacrificing motion capability. This technique is ideal for presenting overhead projector transparencies, for instance, or for use with computer-driven "audiographics".

the issues raised by its implementation. At the same time, a numeric assessment will be conducted to evaluate how well each transportation method addresses the identified needs, and how compatible it is with the existing state infrastructure. It should be noted that conclusions based upon costs and availability of some leading edge technologies such as space-based wideband cellular systems are of necessity somewhat fragile. These conclusions will be identified as *cusp points*, and appear as decision nodes in the attached *implementation tree*. In addition, the computer-based financial model used to compare alternative technologies has been provided to the WECB as a supplement to this document. These two tools may be employed in the future in order to maintain the viability of the implementation plan as new technologies emerge and the costs for mature technologies decrease.

3.1.1 Alternative Technology Evaluation Factors

The applicability and logical future development of each pertinent alternative will be explored in this chapter, both globally and with respect to the Wisconsin environment. Each alternative will be rated for conformance to the following parameters:

1) How well does each alternative address the demonstrated needs?

- For which network element is the subject technology best suited?
- Does the subject technology potentially satisfy the issues rated important by likely users, while maintaining compatibility with future growth?
- Will the technology address issues which have arisen in other states once an operational network is available?
- Will the channel capacity of the alternative keep pace with future demand?
- Is the option suitable for use as a staff development tool and administrative teleconferencing?

2) What are the advantages, disadvantages, benefits and risks associated with each option?

- What is the availability of the subject technology, both globally and in Wisconsin?
- What effect will emerging standards have upon the technology?
- What effect will the regulatory environment have on the subject technology or existing service providers?
- What will be the staffing impact on existing and future users of distance education technologies if the indicated alternative is recommended?

Among the evaluation criteria for the technologies are how well each addresses the needs and what the advantages and disadvantages are.

- What will be the impact on the roles of the local and state level agencies and personnel with respect to the selected scenario?

Other evaluation factors are cost and method(s) of financing and migration / implementation issues.

- Does the alternative have the potential to expedite the availability of educational opportunity to all Wisconsin citizens, especially those in rural and disadvantaged areas?
- What is the likelihood that a given alternative represents a "dead end" technology, fated to be replaced by a more flexible and less expensive option in the near future?

3) What are the order of magnitude costs and financing methods associated with each alternative at both the state and local level?

- What are the tradeoffs with respect to the capital costs of the technique versus long-term savings?
- What are the advantages of leasing versus the purchase of various network components?
- What possible savings are obtainable from the continuing budgets of various state agencies?

4) What are the migration and implementation aspects associated with each alternative?

- To what extent does the alternative utilize the state's existing resources?
- What will be the continuing operational impact on users *system transparency*).
- What are the maintenance issues associated with the option?
- What are the prerequisites upon which implementation of the alternative depends?
- What is the implementation timeline associated with the option?

In the technology evaluation section which follows, each of the alternatives will be assigned a *rating numeric* with respect to each of the four categories listed above.

Each technology is assigned a value from zero (low) to five (high) in each of the four evaluation areas.

The numeric assignment will represent conformance to desired performance according to the following scale:

- 0.0 = Does not conform in any respect.
- 1.0 = Conforms poorly to desired performance.
- 2.0 = Conforms partly to desired performance.
- 3.0 = Conforms adequately to desired performance.

- 4.0 = Conforms very well to desired performance.
- 5.0 = One of the best options with respect to conformance.

A total overall rating will be given to each technology option for every network element for which the alternative is qualified. This overall numeric will be obtained by adding the individual ratings for the four categories together.

3.1.2 Technology Classifications

In the discussion which follows, three different types of technologies are described. The first, referred to as "core" technologies, represent lowest common denominator distance education *delivery components* which may themselves compose portions of other technology alternatives. Examples of core technologies are fiber optics and microwave networks which may be available either as private systems or as value-added networks from common carrier providers.

The second type of technology refers to electronic transportation *systems* which may utilize one or more of the core technologies in the assembly of a larger overall network. These concentrated networks, such as cable TV systems or local telephone exchanges, represent a usable entropy value by virtue of their in-place organizational content.

The third type of technology represents "soft" distance education technologies, and includes *implementation standards* such as compressed video, scanning, ISDN, and SONET.

Identification and a brief description of each alternative considered for evaluation is included in the following tabulation. While it is not within the scope of this document to provide descriptions which would comprise a "primer" for each technology, the descriptions given are deemed appropriate for those persons who are familiar with basic distance education terminology. An acquaintance with the following basic concepts is deemed essential in order to fully appreciate the logic behind the subsequent technology recommendations.

3.1.3 Detailed Technology Analysis: Fiber

3.1.3.1 Description

Fiber optics [1] is a core technology, and is a major component in nearly all distance education systems being planned today.

Fiber is a component in most new systems.

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[1] The terms "fiber optics" and "light fiber" are used interchangeably in this document

Fiber optic cable as a transmission medium can accommodate all known transmission methods and is almost unlimited in bandwidth potential. The evolving Synchronous Optical Network (SONET) and Asynchronous Transfer Mode (ATM) standards will provide end-to-end compatibility across networks managed by different vendors, and will also help make universal *bandwidth on demand* and *access on demand* a reality ("video dial tone").

3.1.3.1.1 Fiber Strands

Fiber optics uses light transmitted through thin glass strands.

Fiber optic technology specifies a means to transmit electronic intelligence (video, data and voice signals) employing modulated light waves propagated through specialized glass fibers. These fibers are formulated with extremely pure silicon glass divided into two annular regions: the *core* and the *cladding*. A slight difference in the index of refraction between these two regions keeps the light "trapped" within the fiber due to internal refraction, the same phenomenon which makes a pencil appear to be bent when it is placed in a glass of water. Light fiber is essentially a "light pipe", and is notably superior to the conventional copper or aluminum coaxial transmission lines used by older Cable TV systems in terms of capacity and extendibility. An additional advantage of fiber optics is that it is secure from outside electromagnetic interference; it therefore does not pick up extraneous radio frequency radiation from industrial machinery or two-way radio which can interfere with conventionally transmitted signals. Conversely, it is not possible to "eavesdrop" on a fiber transmission without actually invading the cable.

Strands are grouped into cables which last up to 30 years and are usually buried underground.

3.1.3.1.2 Fiber Cables

Fibers are generally bundled into *cables* of eight or more, which are usually buried underground.[1] Fiber optic cable is fragile, and usually includes a steel "strength" member in order to prevent bending beyond the recommended radius. Because glass is an amorphous liquid, fiber strands have a definite life which is currently estimated at an average of 20 to 30 years before microbending losses become excessive.[2]

Because of the exposure of the cable to environmental and man-made insults, system designs employing fiber optics must specify an additional power margin, or *loss budget*, in order to account for future cable cuts and consequent splices.

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[1] As an exception, *extension fiber cables* are presently being lashed onto numerous Cable TV overhead strands to extend the reach of the cable system.

[2] The fact that glass is a liquid is not generally recognized. It is nevertheless a semi-amusing fact that if we were to watch a window pane for a few hundreds of thousands of years, we would see it flow and eventually become a useless puddle.

Fiber optic cable is also relatively expensive to install, both because of the physical effort required and the expense of acquiring easements and road crossings. In addition, the equipment presently used to "launch" and receive the light is relatively expensive compared to the comparatively simpler *RF modulators* used in the coaxial cable realm. Offsetting these disadvantages is the fact that an extremely large number of video, data and voice channels can be simultaneously transmitted for relatively long distances on *each* fiber without significant distortion or degradation.

Buried cables can be accidentally cut, and the equipment at either end of the fiber is expensive. However, fiber has very great capacity.

3.1.3.2 Capacity

3.1.3.2.1 Terminology

As mentioned previously, the fiber optic medium is inherently high-capacity. The following digital signaling standards, adapted from telephone company usage, define the units of information carried on most wide area fiber systems in Wisconsin:

- DS-0 = 64 thousand bits per second (64 Kbs): this unit of information is sufficient for one digitized voice circuit or one *Group 4 FAX*[1] circuit plus associated overhead (housekeeping) bits.[2]
- DS-1 = 24 DS-0s plus overhead bits (1.544 Mbs total): this increment is usually used if a great many voice trunks are to be provided, if data speeds

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[1] A Group 4 FAX is a relatively new, high- speed FAX machine. Most FAX machines currently in use are Group 3 machines and operate on a normal analog voice telephone line.

[2] The information is usually carried in the first 56 Kbs with the remaining 8 Kbs being used for signalling and framing. The question is frequently asked: "If each voice conversation carried by the telephone company uses a DS-0, why is my computer modem speed limited to 9600 baud or less?" The primary reason for the limitation is the inefficiencies associated with the digital-to-analog conversion process required to use voice grade lines. For normal telephone connections to the home, a *channel bank* is employed by the phone company to convert the analog signal produced by a standard telephone to digital signals understandable to the fiber network terminal equipment. As an optional product, some telephone companies offer a direct connection to the multiplexer called a *direct digital line*, which allows the full speed capacity of the DS-0 to be utilized. This digital line may be either *dedicated*, which means it is connected all the time and billed regardless of usage, or it may be *non-dedicated* (switched), in which case billing is usage sensitive. It should be noted that the terms *9600 Baud* and *9600 bits per second* are **NOT** interchangeable, since most data transfer protocols add *parity bits* to the data stream in order to assure reception integrity. This results in the file transfer speed being somewhat less than the speed capability of the circuit.

DS-0 (voice circuit), DS-1 (24 DS-0s) and DS-3 (28 DS-1s) are standard measurements of bandwidth, or capacity.

above 56 Kbs and under 1.5 Mbs are to be used, or if limited motion video teleconferencing is anticipated.

- DS-3 = 28 DS-1s plus overhead bits (43.2 Mbs payload): this increment is usually used for full motion video *Level 2* applications such as broadcast television or to combine DS-1s in a digital backbone.

Other signaling standards are available in other states or will be available in Wisconsin in the future, such as DS-4s and SONET.

Fiber has much higher capacity than any other medium.

Information theory demonstrates that the amount of data which can be carried on a medium is proportional to the maximum *carrier frequency* which can be utilized before losses become excessive. For copper coaxial cable with commonly used amplifiers this frequency is approximately 500,000,000 Hz. (500 MegaHertz), for microwave systems, it is approximately 23,000,000,000 Hz. (23 GigaHertz), while for fiber optics it is the electromagnetic frequency of light itself, or approximately 2,143,000,000,000,000 Hz. (2,143 Terahertz for the shortest wavelength, or highest frequency, in general use today).[1] A single fiber therefore has over 93,000 times the theoretical capacity of the highest frequency microwave system,[2] and over *four million* times the capacity of a standard coaxial cable system.

Continued improvements in endpoint electronics will provide large increases in fiber's capacity.

Today's practice is to employ two fibers for two-way transmission, one for the downstream channels and another for the upstream return channels. Although this halves the cable capacity, advances in terminal equipment have the offsetting effect of doubling fiber capability approximately every 5 years, which should keep supply ahead of demand on most routes. To implement new advances in system speed requires only that the electronics be replaced or upgraded; modifications to the fiber cable itself are not generally required (assuming properly installed single-mode fiber is used [3]).

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1. With light, frequency relates to color. Light emitting diodes and lasers in the red and infra-red portions of the spectrum are commonly used, although orange, green, blue and other colors have been employed in the laboratory with dichroic mirrors in a wavelength multiplexing arrangement designed to double or triple the capacity of fiber cable.
2. Because the FCC restricts microwave emissions in order to reduce interference, the real-world practical capacity advantage of fiber optics over microwave is actually even greater.
3. See *Propagation Modes*, Section 3.1.3.3.4, for a complete discussion of single and multi mode fiber

3.1.3.2.2 Fiber Capacity in Wisconsin

An extensive fiber optic cable infrastructure has already been installed by the major Wisconsin telecommunications vendors, notably GTE, AT&T, MRC, Ameritech and some of the independent telephone companies (see Appendix D). Although multiplexing and switching capability is primarily confined to central office interconnects at the present time, the net result is that at least OC-12 capacity (12 DS-3) is readily available on most major inter-city routes. Each established fiber pair of the 8, 16 or 24 fiber cables which interconnect the central offices of the major telephone providers has sufficient capacity for the following example traffic[1]:

- 12 full broadcast resolution channels (Level 2).
- Or 15 Level 3 full-motion NTSC channels.
- Or 30 Level 4 multiplexed NTSC channels.
- Or 336 full DS-1 teleconferences (Level 5).

Today's installed electronics allow a pair of fibers to carry 12 broadcast - quality video channels.

The purchase of new switching equipment readily available from manufacturers today could successfully extend the capability of the installed fiber plant even further:

- 25 Level 2 broadcast television channels.
- Or 30 Level 3 Cable-TV or ITFS full motion TV channels.
- Or 60 Level 4 staff development video telecourses.
- Or 1,344 administrative meeting (1/2 Level 5) teleconferences (one-half DS-1).
- Or 672 wide area network 1.5 Mbs Novell or TCP/IP ISDN connections (DS-1).
- Or 16,128 telephone calls (64 Kbs).
- Or 16,128 56 Kbs Group 4 FAX circuits.
- Or virtually any combination of the above services, such as ten Level 2 channels, ten Level 3 video telecourses, ten full Level 5 teleconferences, 2,000 telephone circuits and 1,900 Direct Digital 56 Kbs *switched-56* or Group 4 FAX circuits **simultaneously**.

The newest equipment could increase this capacity to 25 channels.

The manufacturers of fiber terminal equipment have recently been pushing the capacity envelope even more aggressively. Using switching equipment which will be cost effective within the next five years, the following single-fiber-pair capacities will be available:

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[1] A few vendors have 4-fiber cables installed on some of the older routes, but these are scheduled for replacement in the near future.

Within five years, it is envisioned that the electronics will allow as many as 191 channels on a single fiber pair.

- 95 Level 1 HDTV channels.
- Or 191 Level 2 broadcast television channels.
- Or 230 Level 3 Cable-TV or ITFS full motion TV channels.
- Or 480 Level 4 staff development video telecourses.
- Or 5,375 Level 5 DS-1s.
- Or 129,688 telephone calls (64 Kbs).

At the same time that system capability is increasing, advances in video and data codecs are reducing the bandwidth required for each signal, thereby further increasing the number of available channels. In the long term, wavelength division multiplexing promises to further extend fiber capacity by employing multiple color lasers to allow *each* fiber to carry bidirectional traffic. The convergence of all these forces provides a high confidence factor that fiber optics should be an integral part in the planning for any Wisconsin distance education system today.

3.1.3.3 Implementation Considerations

3.1.3.3.1 Multiplexing Methods

Capacity can also be increased through "multiplexing", i.e. sending two or more channels through a single channel "pipe" at the same time. Two methods for doing this are called Frequency Division Multiplexing and Time Division Multiplexing.

There are two basic methods for carrying more than one signal on a single circuit, be it copper wire or fiber optics:

- *Frequency Division Multiplexing.*
- *Time Division Multiplexing.*

The concept of multiplexing requires some discussion. In brief, two different video or data signals cannot occupy the same space on a fiber at the same time without causing mutual interference which would render the information unintelligible. In order to combine or *mix* two or more signals so that they can be individually recovered, it is necessary to employ a device which assigns each signal either its own *modulating frequency (FDM)* or its own increment of time (TDM). Because multiplexing significantly increases the complexity and cost of a system, it is generally not used for straightforward local applications such as short studio-to-transmitter links where an entire fiber can be dedicated for use by a single video channel.

3.1.3.3.2 Discussion of Frequency Division Multiplexing (FDM)

Frequency division multiplexing separates each signal by a set frequency increment. This is the method used by today's TV sets to distinguish one television station from another; for instance, channel two operates from 54 to 60 MHz while channel three operates from 60 to 66 MHz (cycles per second). Frequency division multiplexing is most often used when *analog* signals are being mixed[1]. Components and equipment for FDM are readily obtained, and the technology is well understood by today's service personnel. The device used to "mix" a number of signals on a single fiber is called a *modulator*, which is similar to a very low power TV transmitter. A companion *demodulator* is used at the receiving end to "filter out" each signal. This technique of mixing is comparatively inexpensive, although the distance the signal can be carried is limited by cascaded noise contributed by trunk and distribution amplifiers. These attributes make analog techniques a logical candidate for interim use in the local loop, and within individual buildings as a Master Television System (MATV).

3.1.3.3.3 Discussion of Time Division Multiplexing

Time division multiplexing combines and separates signals by assigning synchronized small slivers of time to each. To illustrate, the first time slot may contain a piece of signal one, the next slot a piece of signal two, and so on. If there are two signals, the second piece of signal number one is reached at the third clock tick. Obviously, the clock must be ticking much faster than each signal is changing, or information will be lost.[2] TDM is the multiplexing method used in the *digital* realm, for instance by computer networks. TDM requires more expensive terminal equipment than does FDM, and troubleshooting is a somewhat more esoteric art. TDM mixers are referred to simply as *multiplexers*, or *MUXes*, and are rated by **speed** and **bandwidth**. The faster they are capable of operating, the more signals they can mix together; at the same time, differently constructed units are used to combine the various standard telephone data increments. For instance, an *M-13 multiplexer* is used to combine DS-1 (1.544 Mbs) circuits onto a DS-3 (45 Mbs).

Several advantages are associated with TDM multiplexing with respect to FDM:

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[1] FDM should not be confused with *Wavelength Division Multiplexing (WDM)*, which refers to the use of several different color lasers on a light fiber to extend the capacity.

[2] In fact, information theory demands that the clock must run at least *twice as fast* as the baseband signal is changing.

- Propagation over nearly unlimited distances is possible, with virtually no noise.[1]
- Error detecting and correcting codes can be employed.[2]
- Signal processing and mixing is precise and can be exotic (multi-picture screen splits for video, and ISDN circuits for data).

3.1.3.3.4 Propagation Modes

There are two basic types of fiber optic cable associated with the modulation techniques previously described:

- Single Mode Fiber.
- Multimode Fiber.

There are two types of fiber - single mode fiber and multi-mode fiber.

Single mode fiber is the universal choice of telephone utilities, common carriers and long distance cable companies because it allows signal amplifiers to be spaced at greater intervals while simultaneously supporting higher transmission speeds. Large area distance learning networks would undoubtedly utilize single mode fiber for the overlay network if it is provided by common carrier vendors.

Single mode fiber is difficult to couple, and therefore requires a somewhat more expensive launching device (such as a laser). Along with generally higher equipment speeds, the cost of single mode terminal equipment is generally higher than the equivalent cost for multimode equipment. However, these costs become insignificant for larger networks as the capability of carrying signals extremely long distances at high speeds with very low distortion becomes of paramount importance (up to 40 kilometers without amplification). Single mode fiber is used primarily with the digital mode of transmission and TDM.

Multimode fiber would normally be utilized for last mile distribution, especially for runs of less than seven kilometers. Small local networks could either lease multimode fiber or install their own, being mindful of the speed and distance limitations imposed by this technology. Use of multimode fiber does impose a constraint on the upgrade path, so this factor must be carefully evaluated when multimode fiber is costed.

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[1] Absence of noise is not inherent in the TDM multiplexers or demultiplexers themselves. To be perfectly accurate, noise is generated in a digital system to an extent at least equal to that due to a good analog system. With digital *Pulse Code Modulation (PCM)* however, the noise can be "cut off" below peak pulse level and the pulses cleanly regenerated.

[2] Although most computer users are familiar with error detecting codes (as *parity bits*), the concept of error correction seems to defy common sense. If bits are lost in transmission, the receiver essentially declares "don't bother re-sending that last transmission - I know what you meant." This is accomplished primarily by making certain codes or numbers "illegal". For instance, if legal numbers are restricted to "1" and "4", and if a "3" is received it was probably a "4" which was sent since the logical distance from "3" to "4" is less than that from "3" to "1".

Multimode fiber will accept more light power from a less rigidly controlled source (such as a Light Emitting Diode),[1] and therefore less expensive terminal equipment can be used. However, multimode fiber suffers from dispersion distortion which seriously limits the maximum speed and bandwidth of the system. Generally, multimode cable should only be used for short video and data links where high data speed or full compliance with EIA RS-250B is not required. The most frequent use of multimode fiber is in analog FDM systems, although occasional short spans are used with digital codecs.

Single mode fiber allows signals to travel further before they must be amplified, but require more expensive electronics at the endpoints. Multimode fiber signals use less expensive electronics but can't travel as far or as fast.

3.1.3.3.5 Analog Versus Digital Modulation

One of the primary technology issues with respect to fiber optic system design relates to whether the transmission systems attached to the fiber represent digital or analog modes of modulation. For example, digital transmission is best suited for the regional and State Overlay Network applications where long distances between user sites is the rule. Digital systems are easier to design, are generally more flexible and are easily changeable in the field. In the local network either digital or analog networks may be economically employed depending upon the specific application and the estimate of future growth.

Fiber is used in either analog or digital mode. Digital systems are more flexible, while analog systems are sometimes less expensive.

Analog systems generally offer more channels for the same initial dollar investment when compared to digital techniques, but they are not easily amenable to added capability as user needs change in the future. In short, analog systems become more sensitive to the initial engineering design as they grow larger (engineers would say that they exhibit metastability due to design hysteresis). At some point, all analog networks reach the limit where an arbitrarily large investment in design effort will not extend the capability of the system without reinventing the network topology and re-cabling the user terminals. Therefore, when an analog system is designed, the maximum extent of the system should be calculated ahead of time and the resulting limitations included in the system cost factors.

Both digital and analog systems can use either multimode or single mode fiber. Even so, multimode systems usually employ analog techniques whereas single mode systems are generally digitally based for reasons of cost compatibility. One exception occurs in densely populated urban areas where cable companies and some telephone companies prefer to utilize analog systems on single mode fiber for purposes related to inventory control.

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[1] Or even a flashlight, which is a good way to test for continuity.

3.1.3.3.6 Fiber Marketing by Vendors

Fiber networks provided by vendors represent the class of *telecommunications transportation systems* which employ one or more core technologies, and are fully discussed in Section 3.1.6 (*The Public Telephone System*). Several considerations, however, are pertinent with respect to this Section, notably issues relating to fiber availability.

Digital fiber optic capacity is presently marketed in Wisconsin in the following manner:

- DS-0 or 64 Kbs (56 Kbs payload).
- DS-1 or 1.544 Mbs.
- 36 Mbs portion of a DS-3 (remaining DS-1s marketed separately).
- "High-cap" DS-3 or 45 Mbs.

Digital fiber in Wisconsin is currently marketed in a manner which does not give the user direct access to the bandwidth.

The present vendor practice in Wisconsin is to market TDM increments higher than 64 Kbs in a manner which does not allow user access to the multiplexer or the codec. This means that an institution using 36 Mbs video would not have the option of breaking down a portion of its bandwidth into DS-1 increments if it so chose. On the other hand, existing Channel Service Units[1] are capable of allowing access either to a complete DS-1 (for teleconferences, for instance) or to any submultiple for phone, data or FAX purposes. Therefore, there is logic in providing at least some flexibility to the customer in dynamically assigning his bandwidth for the various video data and voice services.

Factors in fiber pricing include existing switch locations, routing choices, FCC tariffs, and PSC regulations.

The design and pricing of a fiber network is a complex task, and involves access to information which today's providers generally regard as privileged. Decisions made by prospective users with respect to fiber feasibility are usually based upon a design and cost model provided by the vendor serving the subject geographic area. This design and cost are strongly influenced by the vendor's mostly invisible choices in arcane matters such as switch locations, the selection of routing to reach inter-LATA *Points of Presence (POPs)* and the applicability of FCC tariffs and PSC regulations.

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[1] CSUs are installed at the customer premises when 24 trunks are used for a PBX telephone system.

The total cost of a fiber system in a single-vendor scenario can be significantly different depending upon route selection, the extent to which the routes are already employed by other users and the method used to calculate compensation.[1] For instance, short last mile connections can frequently be made economically via private microwave or Cable TV, a solution which generally will not be of interest to a Local Exchange Carrier.

This does not mean that there is insufficient competition among fiber carriers in Wisconsin, nor that prices obtained on a given project will be identical from all vendors. It is nevertheless unreasonable to expect that fiber-based carriers should volunteer information which would result in a loss of business to the advantage of their competitors. In many cases, the best solution is to employ an *integrated systems approach*, which may utilize more than one vendor in a network so that each is providing capability where that carrier is most cost effective. The integrated approach may even dictate that a mix of technologies be employed. To provide a single point of contact, the major vendor can either act as a prime contractor, or a third party *system integrator* can be employed.

The past practice by fiber users in Wisconsin has most often been to employ a single vendor to provide the educational institution with the entire network solution. More recently, many consortia and local institutions have followed the more orderly procedure of employing an engineering consultant as part of the negotiation team in order to act as the educational institution's advocate. Such an engineering consultant performs analogous design and supervisory tasks to the services performed by building architects.

Partly to offset costing inconsistencies, vendors are currently making plans for the availability of a synchronous standard called SONET. When fully implemented, SONET will enable significantly reduced costs because of the simplified switching made possible by *Add-Drop Multiplexers*, which can be positioned in bridging locations **between** POPs. OC-3s (three 45 Mbs circuits operating under SONET) are now available on a few selected feeder routes, with OC-12s utilized at high-traffic locations. Increments up to OC-96 are now in the planning stage.

In the future, the implementation of SONET technology should reduce costs by making access to the fiber easier.

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[1] It must be recognized that the vendor consortium known as *Access Wisconsin* is actively attempting to deal with this problem. However, Access Wisconsin does not represent all vendors, and its internal allocation of project business may or may not be in the best interests of potential subscribers.

Fiber is very reliable. However, repairing a broken cable requires specialized skills and equipment.

3.1.3.4 Maintenance of Fiber Systems

Experience with wide area fiber networks in other states has shown that an average of approximately one fiber outage per month per 1000 miles of plant occurs due to both natural and man-made factors, although this ratio may not be assumed to hold rigorously true in Wisconsin. Wisconsin fiber providers usually reserve an additional "protection" fiber pair when one pair is leased, but use of redundant fibers in the same cable does not significantly reduce outage probability since fiber cuts frequently involve the entire cable.

Reliability factors for fiber networks are therefore difficult to predict, since they are not amenable to rigorous mathematical analysis as are microwave paths. For microwave installations, asymptotically higher levels of reliability can usually be achieved by employing more transmitter power, more sensitive receivers, higher gain antennas, and equipment diversity. These calculated figures reflect accurate real-world performance assuming that acceptable system maintenance is available. In order to obtain the highest level of reliability achievable by users of microwave systems, it is necessary to have an alternate routing on fiber systems, especially on the overlay transportation backbone. This is the functional analogue of a "hot stand by" microwave system, but it makes the installation of a maximally reliable fiber network nearly *twice* as expensive as an unprotected system.[1] This potential problem may be reduced if "stand-by" switched services are available at network nodes, and if ring topology is used to supplement the standard "branch and tree" topology.

Splices and repairs to fiber optic cable must be conducted by skilled crews with specialized equipment; this requirement frequently limits regionally-sized fiber optic networks to the purvey of common carriers which are in the video, data and voice business. Similarly, the terminal equipment can be difficult to troubleshoot and repair (see list item #1 under *3.1.3.5.2 Means of Obtaining Access to Fiber*, below).

Local or school-wide fiber systems usually require so little maintenance that they can be serviced by on-site maintenance staff, especially if the institution is large enough to have a physical plant department familiar with MATV master TV distribution technologies. However, a close relationship will still be required with the fiber terminal equipment manufacturer and/or the supplier.

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[1] This does *not* mean that unprotected light fiber is inappropriate for educational uses. The possible frequency and duration of outages should be fully discussed with the provider, however.

3.1.3.5 Wisconsin Fiber Resources

3.1.3.5.1 Availability

Digital transmission over single mode fiber is the most practical and cost-effective way to transmit voice, video and data over long distances. This fact makes fiber especially attractive for backbone network applications, which is the reason that telephone utilities use digital single mode fiber systems to connect their inter-exchange facilities.

The primary routes that would be required for a route redundant statewide backbone for voice, video and data (and which would serve to interconnect regional distance education networks) are already in place. To fully realize the Tier 1 overlay network would require reconfiguration of many fiber optic multiplexers for the backbone segments as well as some reinforcement of existing fiber routes, especially in the Eau Claire to Wausau corridor. The fiber overlay option is discussed more fully in Chapters 4 and 6 of this document.

Digital, single mode fiber is best for long distances. The main routes required for a Wisconsin overlay network already have fiber in place.

Because of the general paucity of wideband switching capability in Wisconsin, along with a fairly low availability of multiplexing equipment at the LEC level, the costs for regional fiber networks are quite high in spite of the extensive in-place fiber plant. The Wisconsin Public Service Commission's rules insist that installation of new fiber for use by educational entities must be fully compensatory when the regulated carriers are involved.[1]

An additional regulatory issue has also surfaced which threatens to make cost effective pricing by at least one local exchange carrier somewhat more difficult. The legal counsel for Ameritech, the Wisconsin Bell holding company, has opined that FCC tariffs may be applicable for circuits which feed broadcast stations and ITFS transmitters because they are inherently *inter-state* facilities. Since precisely this type of hybrid network is envisioned for the Wisconsin migration plan, use of FCC tariffs

There is extensive fiber in the ground at this time. However, there is still a low availability of the required switching equipment, which is quite expensive.

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[1] An explanation of "fully compensatory" is required. On routes such as Central Office-to-Central Office where there is usually already sufficient fiber capacity and terminal equipment, the compensatory price would be the incremental cost for adding and maintaining the additional circuits on equipment which is already substantially amortized. In cases where new fiber must be buried, the installation cost is presently assigned on a 100% basis to the new customer. The only exception to the 100% rule, as per the precedent set in the *Urban Telephone* case in Clintonville, is if the local telephone company has an established plan to place fiber along the same route at some time in the future. In this case, the *Fiber Incremental Pricing* plan assigns the "pioneering" user only those costs associated with early construction, such as the cost of money. Of course, it is also possible that the telephone company's investors or other potential users could pick up some of the cost of new fiber; see Section 6.1.2 *Summary of Recommended Lease Standards* in this document.

would place a severe and unnecessary cost handicap upon the use of what would otherwise be an effective and ubiquitous local interconnect network. To date, Ameritech has been reluctant to seek either a declaratory ruling or a waiver from the FCC. The WECB's own communications counsel, in a letter prepared on June 4, 1993, issued the following opinion:

> " ... there is a solid legal basis to suggest that the fiber facilities [interconnecting educational institutions and ITFS facilities in the State of Wisconsin] would be regarded as *intrastate* facilities for jurisdictional purposes."

In spite of this opinion, however, the availability of low prices on some routes will be limited until the federal matter is resolved to the satisfaction of all parties.

3.1.3.5.2 Means of Obtaining Access to Fiber

Fiber optic resources in Wisconsin can be obtained in a variety of ways:

Constructing a wide area private fiber network gives the user ultimate flexibility, but creates administrative and maintenance concerns. Also, this option is hugely expensive.

1) A potential user could construct his/her own fiber facilities if the appropriate permits and rights- of-way could be obtained. The advantage of this method is that the user would own and control the bandwidth capacity of the entire fiber cable, and there would be no PSC or FCC regulatory jurisdiction. The owner could also make his/her own decision on the choice of fiber electronics with which to illuminate the fiber. Those pairs of fibers not currently illuminated with electronics (dark fiber) could be held in reserve for future use without economic penalty.

The incumbent disadvantage of this alternative is that the owner would have to administer and maintain the system, not unlike the chores performed by a telephone utility. This would require either establishing a relatively expensive maintenance structure to repair the cable and the associated electronics, or contracting with an outside fiber construction company if one could be found with both the necessary resources and the required inclination. In either case, a significant expense would be incurred which would be out of proportion to the capital investment for all but the smallest and the very largest of networks. An administrative structure would also be required to deal with rights-of-way and construction permits.

Experience in other states has shown that private fiber is an attractive option in only two scenarios:

- For campus-wide systems to connect buildings under a common ownership.
- For systems statewide in scope.

2) Fiber capacity can be leased from a regulated or unregulated common carrier on a *service transportation* basis. Using this scenario the user is charged a lease

fee based upon a fixed number of video, audio and/or data channels of specified bandwidth which are to be transported between designated endpoints for an agreed-upon term, normally 3 to 10 years. Usually the codec, multiplexer and the associated maintenance costs are included in the lease, but users are generally not given direct access to the bandwidth. Most fiber leases currently in force in Wisconsin are of this type.

Fiber can be leased on a "service" basis, i.e. the user is charged a fixed monthly fee.

The essential advantage of the service oriented lease is that there is no transportation equipment to be purchased or serviced by the user.[1] Under this scenario, distance education has a minimal impact upon the existing video equipment maintenance staff, although this advantage tends to disappear as the network becomes larger and more complex.

A service lease relieves the user of equipment purchase and maintenance worries; however, adding more channels is usually expensive.

The primary disadvantage of the service oriented lease is that the user receives no immediate benefit from increases in fiber capacity brought about by future technology advances. Every time the user wishes to add one more channel to the system, he/she must negotiate with the vendor from a position of disadvantage, at least until the lease term is over. Even if a relatively minor addition is to be made to the network, such as a stereo audio signal for a TV channel, the vendor's concurrence must be obtained because the user does not have access to the multiplexer or the codecs. Such concurrence must be sought even if the new signal would fit within the existing occupied bandwidth.[2]

Some service-oriented providers make DS-1 circuits available at low cost if 36 Mbs video transportation is leased. This arrangement can be very cost effective if a service oriented lease is already in force, since it provides four DS-1s (@1.544 Mbps) and two 19.2 Kbs channels at a relatively small incremental cost. In general, however, the *bandwidth oriented* lease is to be preferred if available; this would make the entire

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1. Exactly where the transportation vendor's responsibility ends and the user's responsibility begins is frequently the subject of some misunderstanding. Usually, local terminal equipment such as VCRs, TV sets and distribution systems within a single building or campus are considered to be on the *user's* side of the **DEMARC** (the line separating user equipment and vendor equipment). Experience in other states has shown that there is a much higher incidence of failure with respect to improper procedure and faulty equipment on the user's side of the demarc than is due to failures attributable to the carrier. For this reason, it is important that every party involved in a new system fully understand his or her responsibilities. Users should be trained to recognize the symptoms of local equipment failure, and to promptly notify local maintenance personnel.
2. In one particularly egregious case involving a TV station in Chicago, a local cable TV system stripped the TV station video to the bare bones and requested that the station pay for all services being transmitted in the vertical interval (the part of the picture which is not seen but which is frequently used to activate ancillary services such as closed captioning equipment). It is suggested that the user insert appropriate language in service-oriented leases in order to ensure the proper degree of control over terminal equipment.

DS-3 available (*high-cap DS-3*) for use in whatever mixture of fractional band segments are deemed appropriate by the user. In any case, it is envisioned that interactive computer systems will be used extensively in the future for educational instruction. This will make it increasingly important for video distance education networks to accommodate data as well as video in a truly *integrated* manner.

Leasing "bandwidth" allows the user to allocate and reallocate its fiber for voice, video and data circuits as needs change.

3) Fiber capacity can be leased from a local exchange carrier on an incremental basis (leasing *bandwidth*). This technique assigns a given fraction of the fiber capacity to the lessee, usually in terms of occupied TDM bandwidth. For instance, a slot of 45 Mbs bandwidth (DS-3) could be leased which would allow the user to dynamically change the mix of the video, data and voice signals to be transmitted at any time. Literally, the network could be fine tuned day-by-day. This allows the user to interconnect 28 DS-1 high capacity data circuits initially, and then change over to 672 voice channels, 56 1/2 DS-3 Level 5 compressed video teleconferences, or any conceivable permutation of video, data and voice circuits in order to optimize the system for changes in traffic and advances in technology. In this case the codec and multiplexer acquisition and maintenance costs are usually borne by the user, requiring a relatively sophisticated staff technician.

This type of lease is not yet generally available in Wisconsin.

This "bandwidth allocation" type of lease is not easily obtainable in Wisconsin, although several carriers have expressed willingness to explore the concept. For all but the smallest (local) systems, the flexibility of the bandwidth oriented scenario can far outweigh the additional cost for equipment and maintenance. However, to date most of the regional educational networks have not pursued the possibility of purchasing bandwidth because they have neither the expertise nor the time to devote to network management or codec maintenance. At least initially, it would appear that the flexibility associated with this option will require external expertise in most cases, either delivered by the overlay network management team or contracted from outside vendors. The availability of network management is especially critical in order to ensure statewide compatibility in a dynamic environment.

A "pay-as-you-go" lease is most appropriate for occasional users. This option is currently very expensive, but should become less so in the future.

4) Fiber capacity could be leased on a "pay as you use it" basis from excess capacity belonging to private networks ("grey market") or with somewhat more difficulty, from a few of the common carriers. Generally this capacity would be obtained as part of a switched network where relatively small bandwidth increments such as DS-1s could be connected to users having an occasional short lead time application. In general, such capability may be most easily obtainable where existing fiber routes and switches are already installed, for instance, as an existing user of the ICDN network. At the present time, this capability carries a hefty premium in cost, and there is generally a residual "access charge" which must be paid each month whether or not the system is used. For this reason, the pay-as-you-go alternative is not currently cost-effective in the vendor world, with the

single exception of the DS-0, or *switched-56* product. In the future, it is expected that switched width services will be much more readily available, especially if DOA/BITM takes on a remarketing role.

3.1.3.5.3 Fiber Providers

Fiber is available from both regulated and unregulated carriers.

There are several major providers of fiber optic video/data/voice transportation in Wisconsin:

- **MCI** (regulated inter-exchange carrier).
- **MRC Telecommunications, Inc.** (unregulated inter-exchange carrier - MRC supplies the reseller market, while the *Norlite* division sells to the end user).
- **Sprint** (regulated inter-exchange carrier).
- **AT&T** (regulated inter-exchange carrier).
- **GTE** (regulated local exchange carrier[1]).
- **Access Wisconsin** (consortium made up of GTE, Ameritech and the independent telephone companies).
- **Wisconsin Bell** (Ameritech - regulated local exchange carrier).
- **The Local Independent Telephone Companies** (regulated local exchange carriers).

Many of these companies share facilities, and most of them specialize in certain types of traffic and particular geographic locations (see Appendix D, attached).

Of all the carriers listed above, MRC is the only *unregulated carrier*. This means that MRC is not bound to base its charges on PSC and FCC regulations. In the past, the MRC option has been considerably less expensive than using regulated carriers for the leasing of wideband services between major cities.[2] Where significant new construction is required, however, the MRC option is generally non-viable for educational use because MRC does not have access to the broad spectrum of users which can be tapped by the LECs and IXCs to spread out the costs. It should also be mentioned that the demonstrated cost disparity between MRC and the regulated carriers has been steadily narrowing as a result of recent PSC rule modifications and a general increase in fiber customers.

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[1] GTE-Telcom has inter-exchange responsibilities in some other states, but not in Wisconsin.

[2] For instance, the most recently obtained quote to duplicate the WECB broadcast interconnect using AT&T and Ameritech fiber is 300% higher than the existing MRC contract. Rumors have circulated for years that one or more regulated carriers were considering the establishment of an unregulated division, but these rumors remain unconfirmed.

3.1.3.6 Future of Fiber Technology

Fiber is the premier technology for high capacity applications.

Without question, fiber optic technology is the premier communications medium of the foreseeable future for high-capacity backbone applications. It is unmatched for two-way bandwidth capability and flexibility. While peripheral roles will continue to be played by the cellular service (as a wireless umbilical), satellite (including Personal Communications Services [PCS]), cable TV and microwave systems (to by-pass recalcitrant landowners and high-cost last mile carriers), the lion's share of the Wisconsin state communications infrastructure will probably be fiber optics by the year 2015.

3.1.3.7 Network Evaluation

3.1.3.7.1 Use in State Overlay and Regional Networks

Ultimately, overlay and regional networks will be mostly composed with fiber. For local networks, other technologies will continue to offer cost advantages for the next ten years.

Within the time frame represented by the planning horizon, the State Overlay Network and most of the regional networks will most probably be composed primarily of fiber elements, although a peripheral role will continue to be reserved for satellite. Other technologies will be used for purposes of migration, but ultimately they must yield to the limitless potential of light-based transmission.

3.1.3.7.2 Use in Local Networks

With respect to last mile delivery, it is expected that other technologies will compete with fiber over the short and mid term because of a lower cost per channel. Use of last mile wideband cellular and other "virtual office"[1] wireless services is expected to coexist with fiber even beyond the planning horizon.

Beginning in approximately 2007, however, it will probably become increasingly difficult to amortize microwave or other similar technologies before fiber is generally available to the curb. At the same time, existing last miles uses which reflect analog technology should migrate to digital techniques so as to be fiber compatible.

3.1.3.7.3 Addressing Needs

Fiber has the potential to address all the identified needs.

Fiber optic technology has the potential to address all video, data and voice needs identified during the *Needs Assessment* phase of the study.

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[1] *MTel Corporation* of Jackson, Mississippi has been awarded a "pioneer's preference"by the FCC to develop the virtual office radio service.

Subject to some restrictions based upon the method used to obtain access to the fiber, fiber technology is effective for delivery of staff development and training programs either on a scheduled basis or on a demand basis. In short, fiber is the best choice today for those schools whose short and mid term video needs cannot be served through other lower cost technologies such as satellite, two-way microwave or ITFS. Fiber represents the premier technology available within the planning horizon which will economically accommodate large scale interactive multi-media applications (integrated voice, video and data). Fiber systems are currently being planned or implemented by a number of school consortia throughout the state, and these systems are being poised to interconnect with regional networks representing other technologies such as point-to-point microwave and ITFS.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 5.0

Rating for the Overlay Network = 5.0

3.1.3.7.4 Advantages, Disadvantages, Benefits and Risks

Although other technologies presently offer cost advantages over fiber systems, no other transportation method offers the virtually unlimited channel carriage capability and the ease of adding additional channels. With codec equipment steadily decreasing in cost, it is evident that fiber optic technology is poised to become the information highway workhorse as soon as regulatory issues, compatibility issues, and standards are finalized.

Fiber offers the advantages of high capacity and flexibility; the primary disadvantage is cost.

Of course, the primary disadvantage of fiber optics is cost and, for the last mile, regulation problems relating to costs. Pricing issues as they apply to lease providers are more fully explored below under *Telephone System Service Costs*, Section 3.1.6.7.6.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 4.0

Rating for the Overlay Network = 4.0

3.1.3.7.5 Fiber Service Cost Considerations

The primary disadvantages of private fiber include the cost of installation, maintenance and the difficulty of obtaining rights-of-way. Installation of private fiber which uses already obtained rights-of-way can exceed $5,000 to $8,000 per mile if overhead, and $12,000 to $19,000 per mile if underground. Switching equipment for even rather small regional networks can easily exceed $600,000.

Telephone companies which lease fiber are also subject to these same relatively high costs, although rights-of-way are more easily obtained by public utilities because of their access to eminent domain. One of the consequences of the high fiber costs is that route diversity protection is not generally included in fiber lease contracts.[1]

Fiber cost disadvantages become magnified at the last mile.

Fiber cost disadvantages become magnified at the last mile; therefore, other technologies may be more cost effective if used to carry the signal to the final user, at least over the short and mid term and especially if the endpoints are highly dispersed geographically.

Today's fiber systems are usually quoted in a "cost per channel" manner which makes them quite expensive.

Prices may vary among fiber providers.

Carrier-provided fiber systems are gradually becoming more economical and cost competitive with other technologies. However, these systems are usually quoted today in a cost-per-channel manner which can make them quite expensive for typical applications requiring multiple channels with a continuous view. For this reason some digital fiber vendors use a combination of switching and scanning technologies to time-share the fiber. The user reviews for these techniques have been mixed, with the most prominent reaction being that the resulting performance is indifferent at best and unacceptable at worst. Other means of multiplexing are available under "high-cap" leases, such as the utilization of compressed video. For service oriented leases however, only alternate-frame multiplexing or split-screen techniques are available. In the view of this consultant, "scanned" systems are to be discouraged for both reasons of implementation and reasons of integration, in spite of their lower cost.[2] In the future, a greater supply of fiber and the completed capitalization of the installation costs will drive the prices of additional channels down. For statewide network applications, economies of scale could further reduce acquisition costs and make fiber pricing more consistent throughout the state, thereby reducing the pressure to utilize scanning.

The majority of fiber optic systems already implemented or currently being planned are switched digital systems leased from Local Exchange Carriers (LECs). *Access Wisconsin*, a vendor cooperative of LECs specializing in fiber

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1. The difference between *route diversity* and *cable diversity* should be emphasized. Nearly all fiber lease vendors include a *protection fiber pair* with their pricing. The protection pair usually runs in the same cable, however, or at best another cable which runs in the same trench. This leaves both the primary pair and the protection pair subject to failure because of such factors as an inattentive backhoe operator.
2. Besides the operational difficulties associated with voice operated or switch operated scanning systems, it is extremely difficult to design a statewide overlay system which will operate properly with numerous scanned regional networks. In order to be used effectively, scanning requires that the instructor be very skilled in its operation, which goes against the desired goal of system transparency.

based two-way interactive video networks for distance education, has the largest number of quoted systems in Wisconsin.

Although most vendors use a "standardized pricing model", it is nevertheless true that prices from each vendor are not generally the same for every proposed network. Several factors which apply unequally to the Wisconsin carriers have a substantial impact on the design and cost of any new network system. Of course, the most significant factor is whether fiber facilities are already in place or whether they have to be constructed. If facilities are already in place, they have either become part of the utility's rate base or the cost of construction has been borne by a previous customer. Therefore, either the local residential and business telephone users have been assessed a proportionate share of the construction costs, or other pricing arrangements have been made as allowed by the Public Service Commission (PSC). On the other hand, if fiber facilities have to be constructed for sole use by a new system, and the carrier has no plans to place fiber in the same area, the PSC regulations insist that the cost of that construction is to be borne either by the LEC's investors or the user it is intended to serve. Present regulations do not allow such new construction to be put into the utility's rate base on the hope of future business. Obviously, this pricing mechanism discourages new wideband educational fiber construction on the part of both the users and the LECs alike, but, at the same time, it is certainly unfair to expect the ratepayers to finance all new construction. This situation raises several issues, not the least of which is the degree to which subsequent fiber users are being subsidized by the user initially constructing the system.

Present PSC regulations do not allow fiber construction and equipment costs to be priced assuming that future customers will share the facilities; the initial user must bear the entire cost.

To some extent mitigating the above described discouragement of new construction, most of the LEC central offices are already interconnected statewide with fiber facilities. This means that the infrastructure is basically in place to support the largest share of the overlay network as well as a portion of the proposed regional networks. Unfortunately, this heaps construction costs on the local loop or last mile elements that make up the local networks. These costs must usually be borne by the individual user, since it establishes the connection from the school or user site to the nearest serving central office. In those applications where the distance from a school site to the telephone central office is relatively great (i.e. 15-20 miles) the cost of these last mile links can become prohibitive. In such cases an alternative technology like microwave or ITFS might be more cost effective.

Another fiber cost factor is the number of video switching locations on the established network. Video switches are used in the network to concentrate user end points (i.e. schools) and to provide an efficient means to switch "video phone calls" between sites. Optimally, a video switch should be located at the central or geographic midpoint of the network it serves, an operation which becomes steadily more difficult as the network expands.

The total fiber miles in a network also contributes to the cost of the system, especially if the fiber has to be newly constructed. In general, fiber systems are most economical when the total fiber miles from the user end point to the switch are kept to a minimum. For instance, a network with multiple sites 10-15 miles from the switch to the end point would represent an optimum network configuration. If a group of schools in a particular network are located relatively long distances from the switch (i.e. 75-100 miles), it often is more cost effective to dedicate another switch to those remote sites and tie the two switches together with interswitch links in order to form an integrated network. This topology reduces the channel capacity required between the remote sites and the original switch. The links that tie the two switches together are usually engineered according to the amount of anticipated video traffic that will take place between the two groups. If traffic conditions warrant, additional video channels can be added to the inter-switch links. For this reason a statewide video network will most likely evolve as smaller groups of regional network switching clusters interconnected with a statewide overlay network. This is similar to the topology used for the existing public telephone network. Using the above described design methods effectively can make fiber systems much more economical; unfortunately, these parameters are not under user control.

Fiber networks become less cost effective when switch endpoints are far from the switch. It would be more economical to develop two interconnected regional systems.

3.1.3.7.6 Transportation Equipment Cost Considerations

Another significant expense associated with fiber systems is the cost of equipment necessary to interface with the fiber:

- "Codec" coding/decoding equipment for digital systems can cost $15,000 to $30,000 per end depending upon the compression level, while terminal equipment for analog systems is priced at approximately $10,000 per end.[1]
- Multiplexing and switching equipment to mix signals together so that they can be simultaneously transmitted on the same fiber and routed to the correct destination can cost $30,000 to $300;000 for local and small regional systems depending upon transmission speed. Switches for wide area networks can cost several millions of dollars (costs generally borne by the lease vendors).
- Other equipment costs associated with the lease of various increments of fiber capacity (DS-0, DS-1 and DS-3) are discussed in Section 3.1.6.7.6.

Equipment needs on fiber networks include codecs ($15,000 to $30,000 per endpoint) and multiplexing equipment ($30,000 to $300,000)

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[1] To reduce costs, analog endpoints can be "looped" from site to site in the manner of Christmas tree lights. This topology is often employed by Cable TV companies utilizing AM analog modulation. There are serious operational ramifications to these types of systems, however, such as limited ability to expand the system once it is installed. Except in circumstances of very restricted finances, "loop-through" topologies are not recommended.

3.1.3.7.7 Local Equipment Costs

The cost of endpoint electronics (i.e. in a school) must also be considered when pricing networks.

For all private networks and some leased-capacity fiber networks, the local institutions are responsible for the codec costs as tabulated above under 3.1.3.7.6. Even if the codecs are installed and maintained by the carrier, however, there are significant local costs to consider. These costs, as tabulated below, reflect classes of equipment which would be required regardless of the video-based distance education technology used:

- Equipment to provide integration with the existing telephone system equipment and the long distance service vendors.
- Video production equipment.
- Training of personnel to operate and maintain the terminal equipment, manage the distance education network, and anticipate new uses for the system.

As detailed in Appendix R, distance education classrooms can cost from $60,000 to over $100,000 depending upon the features desired.[1] Eventually, it should be anticipated that another staff position will be required at each institution to manage distance technology, unless a full-time media director is already employed.

Rating in the Local Loop = 1.0

Rating for the Regional Network = 2.0

Rating for the Overlay Network = 3.0

3.1.3.7.8 Migration and Implementation Issues

Migration to fiber from other technologies is straightforward.

Migration to fiber optics from other technologies is usually relatively straightforward, especially if analog techniques have been previously used. Because of fiber's enormous bandwidth, virtually any signal being transmitted using other technologies can be placed upon fiber. If "high-cap" transportation is to be used, however, implementation will be complicated by the level of expertise required to utilize and maintain the equipment.

If the prospective user properly prepares the local staff, fiber usage should result in the maximum degree of user transparency, since all anticipated networks and uses are compatible with it.

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[1] Low-cost roll-around camera/control/codec units are available for $20,000 to $30,000 however.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 4.0

Rating for the Overlay Network = 4.0

3.1.3.7.8 Rating Total

The total evaluation numeric for the Fiber System option, obtained by adding the above evaluations together, is as follows:

Rating in the Local Loop = 13.0

Rating for the Regional Network = 15.0

Rating for the Overlay Network = 16.0

3.1.4 Detailed Technology Analysis: Point-to-Point Microwave

Point-to-point microwave is an over-the-air technology in use throughout Wisconsin. It can operate in analog or digital mode and requires FCC licensing of channels.

Point-to-point microwave represents a core technology which is presently in extensive use in Wisconsin both by telecommunications vendors and by users of distance education systems.

3.1.4.1 Description

Point-to-point microwave interconnection systems employ an electromagnetic radio technology which uses free space as the propagation medium. Microwave technology shares many of the electrical characteristics of fiber or coaxial cable, in that most of the transmission standards that apply to fiber also apply to microwave systems (such as the "digital signalling" DS designations). Like fiber, point-to-point microwave transmission can utilize either analog or digital modulation. These microwave systems employ a "one-to- one" mapping, as opposed to the "one-to-many" mapping applicable to broadcast technologies.

3.1.4.1.1 Assigned Frequencies

Microwave systems use channelized frequencies assigned by the Federal Communications Commission in several different bands:

1) High UHF (Ultra High Frequency - 300 MHz to 3 GHz). Present uses are:

- 950 MHz aural STLs.
- 3 GHz video inter-city relays.

2) SHF (Super High Frequency - 3 GHz to 30 GHz). Present uses are:

- 7 and 9 GHz common carrier and TV relay service.
- 11 Ghz common carrier video service.
- 12 GHz Community Antenna Relay Service (CARS - analog transmission only).
- 18 GHz Private microwave video and data service.
- 23 GHz Private microwave video and data service.

It should be noted that the use of "laser links" should be included in the microwave category, although they enjoy the distinction of not requiring FCC construction permits. Frequently, laser "last mile" video or data connections can be accomplished economically for distances up to 2,000 feet if only one or two channels are required.

3.1.4.1.2 Design Considerations

Planning, designing and constructing a microwave system is a highly technical task requiring numerous compromises as well as extensive liaison among the user, the consulting engineer, the vendor, the FCC and the FAA. As is the case with fiber specification and costing, independent engineering counsel is required in order to ensure that an educational institution receives the full benefit of the technology.

Microwave networks must be carefully designed to insure full benefit.

When configuring a microwave network during the initial design phase, a great deal of flexibility is possible with respect to the location of the towers required to support the microwave antennas. Leases or land purchases are required only for the comparatively small piece of property upon which the towers stand. In the great majority of cases, the radio route can be easily configured so as to utilize land parcels, existing towers, buildings or other structures for which building approvals are possible and for which usage is cost-effective.

A typical microwave backbone system would consist of a series of tower-mounted antennas, each of which receives the signal from another similar tower located 5 to 40 miles away. The signal is processed, boosted in power and retransmitted to the next point in the network. Easements for intervening terrain are not required. Video, audio and data signals can be added or accessed at any of the tower locations, and/or transmitted signals can be easily split and sent to multiple receive sites. Locations blocked by terrain obstructions can frequently be serviced by using relay stations, reflectors or "beam benders."

Microwave signals are sent between tower-mounted antennas spaced 5 to 40 miles apart.

Future increases in capacity or the addition of two-way to existing microwave systems can be accomplished relatively readily by installing an additional transmitter/receiver pair; it is generally not necessary to make tower modifications unless another frequency band must be used because of frequency congestion. Similarly, once the backbone is constructed, the network can be extended to new endpoints from virtually any tower site node, although the required additional tower construction makes this technique relatively expensive if a large number of endpoints are added.[1]

Microwave is most effective when a relatively few number of channels are required.

Point-to-point microwave technology is most effectively used for a relatively few number of channels delivered to the last mile from a fiber, cable or satellite backbone.[2]

3.1.4.1.3 Transmission Modes

Microwave systems can employ either analog or digital transmission with equal ease, as well as a mixture of the two modes, even though existing receivers and transmitters cannot be converted from one mode to another. The introduction of digital microwave equipment is a relatively recent event, and as such it is significantly more expensive than an equivalent pair of analog transmitters and receivers (approximately 50% more costly). In general, digital microwave equipment is effective for use as backbone transportation, while analog microwave works well in the short-haul last mile environment.

3.1.4.1.4 Availability of Systems

Privately-owned microwave networks are far more affordable than private fiber networks. Service can also be leased from other providers.

As is the case with fiber systems, microwave networks can either be totally installed by a private owner or capacity can be leased from common carrier providers (either regulated or unregulated). Unlike fiber systems, construction of a local or regional-sized microwave network can be well within the means of school district consortiums or community colleges. For leased scenarios, either service-oriented transportation or leased bandwidth is generally available. "On-demand" service is also usually available from vendors on most high-traffic routes without an excessive cost penalty, but such use requires coordination in advance ("dial-up" service is not available in Wisconsin).

3.1.4.2 Capacity

Point-to-point microwave systems must operate in an environment where the total bandwidth and the number of channels available is limited by FCC regulations and other nearby microwave users.

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[1] Omnidirectional microwave services such as the Instructional Television Fixed Service (ITFS) are more suited to reach a large number of endpoints than is the point-to-point service, although use of ITFS requires that alternate technologies be used for the upstream (return) video path.

[2] One particularly effective use of private microwave is to reach the POPs of the Inter-exchange carriers (IXCs), and for other inter-city relay applications.

3.1.4.2.1 Frequency Bands

Obtaining microwave channels can be difficult in some areas.

Some difficulty is frequently encountered near metropolitan areas in allocating a sufficient number of unused microwave frequencies in order to construct a network. Under the best of circumstances, it is generally difficult to coordinate more than four two-way video channels except on the following bands:

- CARS band (must be a Cable TV entity to apply for these frequencies).
- The common carrier frequencies (must be a legitimate common carrier such as Ameritech or MRC).
- The 18 GHz and 24 GHz bands (requires three to four times the number of tower sites as do the lower frequencies; this generally makes constructing a network comprised solely of these higher frequencies cost prohibitive).

If digital transmitters and receivers are used, these same frequency bands can be used for carriage of video, audio and/or data signals at the normal multiples associated with the DS-3 designation.

3.1.4.2.2 Microwave Capacity Versus Projected Demand

Microwave channels are not generally available in all areas in numbers which a state overlay network would require.

As is the case with fiber based transportation, compressed video's capability to reduce the bandwidth of video and data in the future will undoubtedly increase the capacity of the microwave channels. Even so, assuming that point-to-point microwave were to be the sole backbone option of a statewide network, it is expected that demand would overtake the supply of available frequencies in only a few years of operation.[1] On the other hand, some routes associated with the overlay network could be serviced effectively by microwave technology, especially where existing towers can be employed. Over the long term, microwave use will most likely become successively less compatible with fiber, because increments higher than DS-3 will be unavailable or at least scarce, while fiber synchronizing standards will not be applicable. For the lower cost analog microwave option, the use of modulator mixing techniques causes multiplexing to be highly inefficient. For example, generally no more than one full motion video, two audio and one low-speed data channel can be multiplexed on each assigned channel. Such inefficient usage should be limited to short paths where unwarranted preclusion is not caused to other potential users.

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[1] In the past, the FCC has continued to make additional microwave spectrum available as congestion has occurred. However, this process is expected to be neither timely nor sufficient for Wisconsin's projected usage. The scheduling experiences of the Western Wisconsin Communications Cooperative and the Chippewa Valley Technical College is instructive.

3.1.4.3 Implementation Considerations

3.1.4.3.1 Terminology

For the greatest part, microwave systems are amenable to the same terminology and standards as fiber systems excepting those which are propagation media dependent (such as the single mode and multimode designations unique to fiber). Either *AM modulation* or *FM modulation* may be employed depending upon the frequency band, with FM modulation being more noise resistant but somewhat more expensive. Either FDM or TDM multiplexing may be used, with TDM being employed almost exclusively in the digital mode.

3.1.4.3.2 Limitations

Microwave has limited capacity when compared with fiber.

Microwave's major liability is its limited channel bandwidth capacity, especially when compared to fiber systems. Frequency allocation restrictions on many of the lower microwave bands generally limit microwave links to four full motion analog video channels in congested areas. Use of digital microwave and compression technology is usually confined to the bands 6 GHz and higher; however, it is generally difficult to coordinate more than three DS-3s on frequency bands below 18 GHz. The frequency bands 18 GHz and above can be used only for very short hops.

Similarly, more than four channels per link can usually be coordinated only on the 18 GHz and 24 GHz bands. As previously stated, exclusive use of these high frequencies is generally not economically viable for most backbone applications because the number of required tower sites is excessive.

3.1.4.3.3 Utilization

Nevertheless, microwave is a good technology choice for some network applications.

For many relatively distinct rural and semi-rural local and regional applications, analog microwave is an excellent choice because it only requires control of the endpoints. For the overlay portion of the statewide distance education network, point-to-point microwave could be used both as a transitional technology and to provide certain links for hub interconnection and route redundancy. For example, use of microwave to reach some of the more remote broadcast TV and FM transmit sites from IXC POPs would undoubtedly be cost effective for both the short and mid terms.

Where advantage can be taken of in-place resources, such as the existing DOT/DSP network, digital microwave radio is expected to play a significant role in the transmission of DS-0, DS-1 and DS-3 signals on an inter-city basis.

Microwave technology is relatively easy to implement from existing tower sites, but new locations require a substantial approval cycle (see discussion below under *Approvals Required.*) It is expected that the microwave solution will be used in cases where easements cannot be obtained, or effective capacity is not available from vendors.

3.1.4.3.4. Approvals Required

Generally, local zoning approval must be obtained to construct a microwave tower, as well as clearances from the FCC, FAA, Wisconsin Bureau of Aeronautics, various frequency coordinating committees and DILHR. FCC, FAA, DOT/BOA and DILHR requirements relate fairly well with reasonable safety concerns and structural integrity, but local zoning hearings can be capricious, unreasonable and emotional affairs requiring careful groundwork by expert land use people and structural engineers. There are numerous cases where improper preparation for zoning hearings has invalidated tens of thousands of planning dollars.

New towers often require an exhaustive approval process.

3.1.4.3.5 Peripheral Equipment

Microwave links are established using antennas employing *parabolic reflectors*, which work on the same principle as a flashlight reflector in that they concentrate the energy in a particular direction. Power is delivered to the antenna via a *waveguide*, which is a special type of transmission line which traps the radio signals within a hollow rectangular pipe.[1] Many transmitters and receivers can share the same waveguide and antenna by employing special isolating devices called *circulators*. This capability results in a fairly cost-effective expansion of channel capacity on routes where frequency congestion is not a problem.

3.1.4.3.6 Reliability

All microwave paths are subject to *fade* due to rain, fog and atmospheric layering. Paradoxically, the statistical nature of this fading is amenable to precise calculation, and any arbitrary level of reliability can be designed into the system if it is taken into consideration at the **planning stage**. It must be emphasized that **there is no excuse for a microwave system to perform in an unacceptable manner** if the system was designed for the reliability level appropriate to the user, and if it was constructed according to good engineering practice. Sample reliability levels are:

Although weather-related outages do occur, a properly-engineered microwave network is very reliable.

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1. Waveguide is the microwave functional equivalent of light fiber, although it is considerably larger in diameter and is useful over a relatively narrow range of frequencies.

- 99.9999% (1 minute per year of outage) - Data circuits and Level 1 TV resolution (usually given in terms of *bit error rates* or BER. Example: 10 to the -12 power).
- 99.999% (5 minutes per year of outage) - Broadcast TV relays (Level 2 TV).
- 99.99% (53 minutes per year of outage) - Cable TV and ITFS relay (Level 3 and Level 4 TV).

Of course, the higher the reliability level, the higher the equipment cost for items such as antennas (up to 12 feet in diameter) and Low Noise Amplifiers (LNAs). Specialized techniques such as antenna diversity (using two antennas separated vertically on the same tower) can be utilized in difficult cases (for instance, over-water paths).

For the most part, microwave signals follow a *line of sight path*, which means "if you can't see it, you can't serve it".[1] Interestingly, however, the converse is *not* true: in some cases you can't serve it even if you can see it. This last event is relatively rare, but it can occur if there are metallic or other reflecting services near the mid-point of the path which cause wave reversal and interference pattern cancellation.

Microwave path studies are called *terrain profiles*. These studies usually take the form of graphs which account for variations in ground elevation as well as the curvature of the earth so as to predict the performance of microwave paths for which visual verification is not possible. Terrain profiles are usually generated from computer databases which contain ground elevation and tree information for the area to be served. These determinations are then verified by "flying the path" in order to ascertain whether buildings, water towers, or other man-made obstructions are in the way. The major source of difficulty with microwave links is the failure to allow sufficient clearance for trees and other obstructions which may "grow" into the line-of-sight path as time goes on.

3.1.4.4 Maintenance

Microwave system maintenance is readily available from vendors.

Maintenance of an installed microwave system is a task generally beyond the capability of educational institutions. Fortunately there are numerous vendors with the resources and expertise to contract for these services, although some staff oversight is necessary to ensure changes made by maintenance personnel do not invalidate the original system design.

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[1] For purposes of complete accuracy, there is some refraction (bending) which occurs over the horizon, which is dependant upon local air dielectric factors (generally taken to be 4/3 of earth radius).

Experience has demonstrated that the number of failure incidents per route-mile is slightly greater for microwave paths than it is for buried cable, primarily because of transmission line and antenna associated deterioration. The costs of repair for microwave systems is usually somewhat more than for buried cable if the paths are relatively short. However, for a high number of route miles, the microwave maintenance costs are generally somewhat less than are associated with buried cable, reflecting the effort and equipment required for digging and splicing. Comparisons of microwave maintenance costs with fiber optic cable should be made with care, however, since even the most resilient of today's cables suffer from microbending losses which impact the long-term reliability in a manner which is not yet fully appreciated.

3.1.4.5 Wisconsin Microwave Resources

Numerous microwave networks are currently in operation throughout Wisconsin.

Probably the most extensive of the microwave networks in Wisconsin belonging to a common carrier is that utilized by MRC. This network visits most major communities in Wisconsin, including Milwaukee, Madison, Green Bay, Wausau, Stevens Point, Wisconsin Rapids, Park Falls, Eau Claire, Marshfield and River Falls. In addition, connections are provided to the Teleport satellite uplink in Chicago and to the city of Minneapolis. The MRC network carries several full time video and aural services, including the WECB's broadcast network interconnect. The WECB is the licensee of several short hops which interconnect the MRC network with some of the broadcast TV studio sites, notably in Green Bay and Duluth.

The most extensive private microwave network in Wisconsin belongs to the Wisconsin Department of Transportation. The primary purpose of this network is to interconnect the repeater sites used by the Division of State Patrol, the Division of Highways, and the Division of Emergency Government (operating under the Department of Military Affairs). The system is well designed and incorporates route redundancy so that the loss of any one tower will not disable the system. The DOT/DSP network visits all major population centers via primary highway routes, and access to the Federal Interstate right-of-way will allow network command and control via dedicated light fiber.

Examples of some of the smaller regional point-to-point microwave systems employed in Wisconsin are:

- Western Wisconsin Technical College (La Crosse area).
- Chippewa Valley Technical College (Eau Claire area).
- Fox Valley Technical College (Appleton area).
- Northcentral Technical College (Wausau area).

- Western Wisconsin Communications Cooperative (CARS band in Trempealeau County).
- Lakeshore Technical College (Sheboygan area).
- Wisconsin Educational Communications Board (Chilton, CATO and Green Lake).

3.1.4.6 Future of Point-to-Point Microwave Technology

Although use of microwave for network backbones will be replaced by fiber, microwave will continue to play an important role in future systems.

Because of a limited bandwidth capability, point-to-point microwave systems will surely be phased out for duty as network backbones shortly after the turn of the century. The advent of digital transmission and compressed video will slow this process, but will undoubtedly not stop it.

For service at the system periphery, however, dish-to-dish microwave should continue to be useful at least up to the year 2015 as a means of cost effective last mile video, data and voice delivery, and as a means of reaching isolated sites where buried cable is not practical. This time frame is sufficient for the required microwave equipment to be fully amortized if installed today for its proper functional role.

3.1.4.7 Network Evaluation

3.1.4.7.1 Use in State Overlay Network

Use of point-to-point microwave technology as an interim element of the state overlay network is both expected and recommended, at least until sufficient fiber optic resources are in place and cost effective.

This important role will be seen in all three areas - overlay, regional, and local networks.

3.1.4.7.2 Use in Regional Networks

Use of point-to-point microwave in the regional networks can be cost effective up to the present planning horizon in locations where frequency congestion is not a problem.

3.1.4.7.3 Use in Local Networks

It is anticipated that extensive use of point-to-point microwave will occur at the local network level. Some of these local microwave systems may well migrate into wideband cellular networks.

3.1.4.7.4 Addressing Needs

Where relatively few channels are required, microwave could serve in a backbone capacity during the migration period, especially where in-place tower resources can be utilized. However, microwave's most extensive use will most likely be to serve as an inter-connection link between fiber networks and the other two-way regional and local interactive networks already in place. Microwave can be a cost effective media to connect node points when other methods prove to be too expensive or are not available.

Microwave links would meet most of the needs identified in the *Needs Assessment* for all three network elements, but would eventually constrain growth because of the limited channel capability. On the other hand, microwave can be implemented relatively quickly where supporting structures are available, and this could be extremely attractive in last mile applications where new or additional channels are needed.

Microwave can meet most of the needs but is constrained by capacity limits.

For some local applications, such as the interconnection of VTAE campuses, microwave could offer a good mid-term solution (up to approximately the year 2015), especially since lease payments are not required after the capital cost is paid. Local PBX, computer data, and video requirements (both full NTSC and compressed) are a good fit for microwave use, thereby enabling staff development and training programs.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 3.0

Rating for the Overlay Network = 2.0

3.1.4.7.5 Advantages, Disadvantages, Benefits and Risks

Point-to-point microwave is a mature technology which is readily available at most locations throughout Wisconsin. It accepts most EIA and other pertinent standards, and can even interface with ISDN and SONET.

Microwave transportation is available from both regulated and unregulated carriers, and can be employed in private networks as well, resulting in a unique degree of implementation flexibility.

Video, data and voice traffic carried by microwave systems must be carefully monitored, so that change-over to a higher-capacity technology can be properly planned. In addition, systems must be carefully designed so as to achieve the required degree of reliability.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 3.0

Rating for the Overlay Network = 2.0

3.1.4.7.6 Cost Considerations

Microwave is relatively inexpensive for the first channel.

Microwave is relatively inexpensive for implementing a first channel and is also cost effective for joining isolated sites to a network in geographic areas where frequency congestion is not a problem.

Recently, price breakthroughs have made the costs of digital microwave radios very competitive with analog solutions for video, data and voice transportation. For instance, 18 GHz hot-standby[1] transmitter/receiver terminal units cost approximately $40,000 per end for a DS-3 solution. Only the multiplexers and codecs need to be added to this cost if FCC licensing, antennas and tower structures are in place.

CARS band microwave is especially cost effective, although it has some restrictions.

A unique microwave service available to cable company operators is called the *Community Antenna Relay Service (CARS)*. Instead of using the more expensive FM (Frequency Modulation) technology, the CARS band uses AM (Amplitude Modulated) microwave techniques which allow a substantial savings on the receiver end of the microwave chain. For instance, a CARS band transmit site may cost $150,000 for ten channels (plus tower and land), but all receive sites which are served from this transmit location can employ a $9,000 receiver and a $2,000 antenna. This receiver employs a block-converter which will directly translate the microwave frequency band to the TV frequency band for use in Master Antenna systems, thereby further reducing costs.

Although licensing on the CARS service is restricted to Cable TV companies, agreements can be made with third parties to carry the signals if they have a legitimate reason, such as carriage to other cable-connected endpoints. As an example of this type of system, the Trempealeau Valley Communications Cooperative uses a CARS band transportation system.

Last mile local connections which employ microwave technology typically employ 24 GHz analog DS-3 combination antenna/terminal units. These units are available for approximately $25,000 per end and are fairly effective over paths up to approximately seven miles in length.

Although strictly not a microwave technology, mention should be made of laser links (such as is supplied by the American Laser Company) which can carry video channels over a distance of approximately 2,000 feet for a cost of under $9,000 without the necessity of FCC licensing or obtaining rights of way.

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[1] The term "hot-standby" refers to the capability of a microwave transmitter and receiver to instantly and automatically transfer control to backup electronics when a failure occurs.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 4.0

Rating for the Overlay Network = 4.0

3.1.4.7.7 Migration and Implementation Issues

Migration of microwave systems to digital technology is relatively straightforward. After the implementation of digital transmitters and receivers, the interface with fiber optic technology is reasonably inexpensive.

Migration of microwave systems to digital technology is straightforward.

The microwave option makes good use of existing Wisconsin state resources.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 4.0

Rating for the Overlay Network = 4.0

3.1.4.7.8 Rating Total

The total evaluation numeric for the microwave option, obtained by adding the above evaluations together, is as follows:

Rating in the Local Loop = 16.0

Rating for the Regional Network = 14.0

Rating for the Overlay Network = 12.0

3.1.5 Detailed Technology Analysis: Satellite

Satellite video and audio distribution is a core technology which is ubiquitous in Wisconsin at nearly all educational strata, from K-12 institutions to the university and college level.

3.1.5.1 Description

3.1.5.1.1 History

In the mid 1950s, British science fiction writer Arthur C. Clarke wrote an imaginative story in which he proposed that a radio "transceiver" (transmitter/receiver) could be located in space at a certain precise distance from the earth so that it would circle the globe once each 24 hours, thereby appearing to be stationary in the sky. The magic "belt" where this is possible is located directly above the equator approximately

23,200 miles high, where the speed required to maintain the satellite in orbit against the force of gravity is exactly matched by the rotation of the earth.

A satellite is a piece of equipment which receives signals from Earth and retransmits a stronger signal back to Earth.

The advantage of this *geosynchronous orbit* is that the earth receiving station, or *downlink*, need not "track" the satellite across the sky in the manner of military spy satellites, which employ lower altitudes. To fix upon a given geosynchronous satellite, the earth station can be locked at one bearing and elevation which is dependant only upon the geographic coordinates of the receiving station and the position of the satellite in the "belt" (generally given as degrees of longitude at the equator).

3.1.5.1.2 Technical Summary

The satellite itself, as it is used in the United States, is actually a multi-channel *repeater* which is capable of receiving a number of video-compatible FM modulated video, data and voice signals from any number of uplinks which may be located anywhere the satellite may be "seen" (locations where the satellite is above the horizon). The uplinked signals are translated in frequency slightly and amplified so they may be received by a reasonably sized downlink (generally 3 meters or less) located nearly anywhere within the continental U.S. and Hawaii. Some satellites, such as the Anik series, also service portions of Canada. The satellite component which performs the frequency conversion and amplification for a single wideband channel is known as a *transponder*.

Satellite signals can be received virtually anywhere using a moderately-priced dish, or "downlink".

The primary advantage of the satellite option is that once broadcast programming is placed on the satellite, the signal is receivable virtually anywhere merely by expending the relatively moderate effort and cost of building a downlink (the ever-present satellite receive terminal seen in numerous backyards throughout the country). The more receive sites to which programming must be delivered, the more cost effective the satellite option becomes.

PBS is very active in satellite, thus ensuring it will play some role in distance education systems.

One significant issue pertinent to this study is the availability of AT&T's Telstar 401 satellite. PBS and SERC are making significant plans for using this satellite to set up a national distance education system for video and audio. Given this fact, it is to be expected that some role for satellite technology would be logical in nearly all distance education systems if only to avoid carrying signals on the transportation network which can easily be obtained directly at the location of the end user or the regional hub center. As part of a migration plan, satellite transponders can be used to deliver locally-produced broadcast programming during the period vendors are establishing the terrestrial fiber optic network.

Satellite is also very effective for use in conducting occasional teleconferences by using either a portable or a permanent small aperture uplink.

3.1.5.2 Capacity

Satellites use two main frequency bands: the older, analog C band and the newer, analog or digital Ku band.

There is room for at least 30 satellites in the satellite belt which can be viewed from North America (assuming two degree spacing), each of which could be addressed merely by pointing the receive dish at the longitude assigned to that satellite. At the present time, there are approximately twenty satellites in assigned locations, five or six of which carry programming of interest to educational institutions. Each satellite usually employs 20 to 25 transponders, not including back-up transponders.

Active satellite technology uses two main frequency bands: the older C-Band (6 GHz up and 4 GHz down) primarily employing analog transmission for video, and the newer Ku-Band which uses both analog and digital video modes. Digital transmission for audio circuits is used extensively on both bands. The most recent development in the satellite field is the Advanced Communications Technology Satellite (ACTS), which is a high-power satellite using the Ka band. Although no major educational programming is scheduled for the ACTS satellite at this time, it is often mentioned in discussions of the future of educational satellite technology.

On C-band, each transponder can carry one analog full-motion TV signal as well as five or six voice or low-speed data *subcarriers*.

On the Ku band, each digital transponder is 54 MHz wide, and generally is divided into "eighths" (e.g. Telstar 401 managed by PBS under contract from AT&T). Each 1/8 transponder exhibits sufficient capacity for one compressed video channel of essentially "entertainment quality" (Level 4 resolution), which is one step below the caliber this document has been referring to as being compatible with the delivery of credit courses. At the present stage of codec development, it would take 1/4 transponder to reach Level 4 resolution, and 1/2 transponder to transmit programming sufficiently detailed for use by a Level 2 TV broadcast facility.[1] These transponder-to-resolution ratios are due to change in the near future, however (see Section 3.1.5.6 below - the *Future of Satellite Technology*).

As of this writing, PBS has leased extensive capacity to the Satellite Educational Resources Consortium (SERC), and has no more transponder space available. However, if enough interest is shown by third parties, PBS may purchase another transponder from AT&T in the near future. The states of Louisiana, Georgia and Mississippi have expressed such an initial interest, as has Wisconsin as part of the instant distance education study.

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[1] As a rule of thumb, the factor 0.6, multiplied by the data rate requirement in megabits per second, yields the necessary transponder bandwidth in Megahertz.

Although new compression technology allows more channels on a satellite, the replacement of old satellites has been slow and demand is overtaking supply.

The process of placing new satellites into orbit to replace aging satellites and to increase capacity has been considerably slowed because of the Challenger disaster and the consequent launching delays. Although there is adequate capability at the present time, it is expected that a full statewide commitment to satellite technology without alternate relief paths would result in severe shortages within the next five to seven years.

3.1.5.3 Implementation Considerations

3.1.5.3.1 Options for Acquisition

To originate and receive programming, an "uplink" is required. To receive, only a downlink is required. .

There are three fundamental uses for traditional satellite technology in the distance education framework:

- As a fulltime and complete one-way wide band video (DS-3) delivery vehicle, from the studio through an uplink to the downlink at the end user's site. This mode allows the transmission of distance education programming over extremely long distances, by-passing terrestrial based carriage.
- As downlink reception only of third-party programming, received either at the head end of a regional distribution system or directly at the location of the end user institution. This mode enables educational institutions to receive and distribute programming supplied by a wide area video broadcast supplier such as PBS, either with or without an audio return response channel.
- As primarily a wideband video downlink system with occasional uplinked programs to be distributed to end users.

In addition, **VSAT satellite** technology may be available to the educational broadcaster in the future. This system, pioneered by Hughes and K-Mart, can be used to deliver narrow-band services (up to 128 Kbs) on a two-way basis (see Section 3.1.5.7 below - *Special Considerations for VSATs*).

Users may lease a portion of a satellite for full-time use or may purchase time as needed.

In order to obtain access to satellite transponder time, there are three primary options available to the distance education user:

- Users may lease entire transponders or a fraction thereof from the satellite owner or time manager in order to obtain 24 hour access.
- Users may lease available time from a broker (reseller).
- Users may form a consortium and lease large blocks of time from the satellite owner or time manager.

If uplinking-on-demand is contemplated, as under the complete delivery system scenario, there are three ways to accomplish it:

- Construction of one's own uplink.
- Leasing uplink time from a common carrier, such as MRC.
- Sharing an uplink with another educational institution.

Uplinks may be purchased by the user or shared/rented from other users.

When choosing to implement a satellite system, several other issues must be addressed depending upon which of the above decision paths are taken. For instance, constructing an uplink is a fairly costly process, especially if it is to employ the degree of redundancy required to achieve 99.999% up time (similar to that easily obtainable with point-to-point microwave). Uplinks must be licensed by the FCC so that interference is not caused to satellites or other downlinks, and unless a complete transponder is leased, a staff member must be designated as liaison to coordinate uplink time with the satellite time manager.[1]

Uplinks must be licensed by the FCC.

If an uplink is to be used which is not located at the site of the educational institution, lease costs and/or capital costs must be included for video transportation to and from the uplink. If the uplink time is leased or shared, a mechanism must be worked out to resolve programming conflicts, which involves a scheduling committee including members of all interested parties.

3.1.5.3.2 The Two-way Issue

Undoubtedly the thorniest problem with respect to using satellite transmission is how to implement the upstream path in order to enable two-way video. If frequent uplinking is required at geographically disparate locations, the return path can be established by designating "hub" or "node" facilities at strategic points in the distance education network, each of which is either equipped with an uplink or has access to one. Individual institutions then would connect to these hubs via an alternative technology, such as fiber optics or microwave. If the uplink time requirement at a particular institution is more occasional than would warrant a fulltime uplink connection, a portable uplink facility may be used at the end user's site.

The main challenge when using satellite is how to implement two-way video from multiple sites.

In order to reduce the uplink cost at node sites, use can be made of a product called a *Small Aperture Video Terminal* or SAVT. This is a 4.5 meter uplink dish which generally costs less than half as much as a Level 2 broadcast uplink, and utilizes left-over transponder space called *SCPC carriers. The resolution of this system is compatible with Level 4 signals.*

Regardless of how the two-way aspect of satellite distribution is accomplished, a discomfort level is associated with the two-way engineering design process. In the case of the uplink hub concept utilizing technology available today, the designer may well establish an essentially parallel network to interconnect the end users to the hubs. As this alternate network grows, it could easily be made bidirectional, and may result in terrestrial links which could bypass the hub uplink and compete with it. This possibility should be carefully considered in any migration plan in which satellite technology plays a part, to ensure that the satellite subsystem cost can be fully amortized, especially since future per-channel costs on fiber cables are expected to decline faster than prices for satellite slots. As an additional factor, some uses of wideband data transmission are not appropriate for satellite carriage at the present time, leading to the possibility of yet another required alternate path for high speed computer traffic.

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[1] It is not possible to merely "turn on" an uplink when one wishes to begin programming. Time segments on individual transponders must be coordinated in advance to ensure there is only one uplink at a time trying to use any individual transponder.

Making a satellite two-way network often involves actually creating two parallel networks.

For use as a ubiquitous one-way delivery vehicle of broadcast type programming, the satellite system is without peer. For this reason alone, it will almost certainly form part of the technology mix and migration strategy when the Wisconsin distance education system is designed (depending upon costs, it would be perfect for delivery of programming to the State TV and FM stations as well as to the ITFS narrowcast sites during the period that the statewide terrestrial network is being developed). The precise role of satellite technology would have to be carefully formulated, however, in order to avoid discouraging program origination by potential end users.

3.1.5.4 Maintenance

The three components for a satellite distribution system which require maintenance are:

- The Uplink.
- The Downlink.
- The Interconnect System (if uplinks or downlinks are located off site).

Maintenance of satellite equipment is generally available; downlinks are usually maintained by the owner.

Arrangements to obtain maintenance on the uplink are usually made at the time that the dish is purchased. Service is generally available from a variety of vendors, and is reasonably cost effective.

Service on the interconnect system is generally performed by the transportation vendor or the user's staff (see Sections 3.1.3 and 3.1.4 above for considerations with respect to fiber optics and point-to-point microwave).

Concerning the downlink, the responsibility for maintenance generally falls to the institution using it. Listed below are the four basic components included in the downlink:

- The parabolic reflector.
- The reflector support and steering system.

- The feed system (LNA, LNB or LNC).
- The receiver.

Maintenance on the reflector and the support and steering system can usually be handled by existing maintenance staff with a very small additional time load. Maintenance to the feed system and the receiver is more complicated, but many schools have been successfully managing the maintenance of these components by employing redundant systems. The non-functional component is replaced from local inventory and shipped back to a depot repair station. In most cases, this procedure is preferable to utilizing a local satellite dish installer, who may have limited expertise with educational quality downlinks.

3.1.5.5 Wisconsin Satellite Resources

All satellite programming originated by NPR, PBS and SERC as well as the other major educational providers is available in Wisconsin through the simple means of installing a downlink at the end user's location. There are several dozen educational institutions in Wisconsin utilizing SERC programming, for instance. The footprint for some of the older satellites (such as Satcom) may be relatively weak in northern Wisconsin, especially near the Michigan border, but the signals may be adequately received by oversizing the dish slightly.

All the major educational satellite signals are available in Wisconsin. WECB has extensive uplink and downlink capabilities.

The WECB Technical Operations Center (TOC) on the Beltline Highway in Madison employs several high-quality downlinks and a Ku band uplink, as well as a dedicated connection to the MRC statewide microwave distribution system and the *Teleport* uplink facility near Chicago, Illinois. The WECB has previously scheduled numerous teleconferences on behalf of educational entities throughout Wisconsin, and regularly makes arrangements through MRC and other carriers to establish upstream paths for NTSC program dissemination. Some of these programs and teleconferences are sponsored jointly by WECB and UW.

3.1.5.6 Future of Satellite Technology

New developments will allow more channels to be put on existing satellites.

For the short term, it is expected that a shortage of transponder space will slow the development of extensive and inexpensive satellite services. In spite of this paucity, one scenario exists for which the satellite capacity time line appears to fit rather handily. Intensive research at both PBS and CBS has provided convincing evidence that sufficiently "smart" codecs using extremely fast microprocessors will be able to reduce the transponder bandwidth requirements for each of the resolution modes by one-half. By 1995, if all goes well, a lease specifying one-half transponder would enable a Level 2 broadcast resolution signal while leaving room for two Level 3 credit-course programs. In the case of Wisconsin, this would allow initial replacement of the broadcast interconnect at a recurring cost 40% higher than the present system while providing two additional video channels which could be dedicated to narrowcast services beginning in 1995.[1]

The longer term outlook for satellite capability is much different, however, and involves several exciting possibilities which collectively must be identified as migration plan cusp points for the early 21st Century. There are currently several proposals working their way through the FCC and being evaluated in laboratories which explore advanced satellite concepts and new multiplexing techniques:

Further in the future, new satellites will offer much more capacity using much smaller dishes. Voice, video, and data transmissions will be included.

- The Motorola *Iridium satellite system* using 77 low-earth orbit satellites as a "reverse cellular network" in which the individual cell sites orbit the earth every 100 minutes or so and "hand off" to each other as they descend beyond the horizon.[2]
- The Personal Communications Service (PCS)[3], also employing high power low orbit satellites.
- High-power wideband (DS-1 level and above) VSATs (Very Small Aperture Terminals) which would enable two-way video teleconferencing using relatively inexpensive two meter dishes.
- Spread Spectrum Techniques using *Code Division Multiplexing*, which allows much denser packing of transmitted signals so that simultaneous transponder access by many earth terminals is possible.
- "Packet" Techniques, which eliminate the need for separate transmit and receive frequency bands.
- Wideband cellular services, which could deliver satellite-based communications to portable and mobile devices without the need for complex antenna systems.

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1. This scenario assumes that the fiber optic option does not continue to plummet in cost.
2. The element Iridium has 77 electrons orbiting its nucleus. Ironically, the latest proposal by Motorola changes the number of satellites to 66 as a cost reduction measure.
3. On December 5, 1991 the FCC held hearings to receive comments on the proposed new PCS service. This service would use the 1.8 to 2.2 GHz spectrum, and would target small pager-sized personal communicators which would receive audio and perhaps slow-scan video. Final adoption of PCS is far from certain however, especially since AT&T objects to the frequency allocation proposed.

The net result of these proposals is that some form of space-based wide-bandwidth two-way service will ultimately become available through employment of high-power transponders and very small antennas (in the limiting case, the antennas for video services will be no bigger than today's VSATs, while audio and low-speed data services could utilize antennas about the same size as those currently employed by cellular telephones). The theoretical limit to the number of channels which could be employed in a given area, while not as large as the number attributable to fiber optic systems, is very large indeed.[1]

3.1.5.7 Special Considerations for VSATs

The transceiver-equipped VSAT as it exists today is limited in bandwidth to approximately 128 Kbs, but in its fully-configured form it represents access to the only extensive *fully two-way* satellite network in use today (managed by Hughes).[2] VSATs are divided into two primary types:

- Single Channel per Carrier (SCPC) VSATs which utilize one-way analog technology to carry audio and data signals. Slightly larger VSAT dishes can also be used to simultaneously multiplex video onto SCPC carriers.[3]
- Fully two-way digital VSATs which utilize data rates of up to 128 Kbs today, and promise higher rates in the future. These VSATs have been used successfully for multi-point two-way compressed video teleconferences as part of joint pilot project by Hughes and Norstan Communications.

Emerging VSAT technology will allow two-way communication, but is costly and is not yet suitable for full-motion video.

The installation of a two-way VSAT requires two primary components:

- Purchase of the integrated dish/transceiver itself, which consists of a compact and sophisticated transmitter and receiver along with a TDM controller.
- A leased line connecting the site with the network node control station.

The data rates generally available for VSATs today can carry 20 KHz audio signals (sufficient resolution for use by broadcast FM stations and for sub-Level 5 "talking heads" video teleconferencing). However because of node control costs, use of this technology for the Wisconsin FM network is presently not feasible. PBS has made *one-way* VSAT service available at rates of 64 Kbs and 128 Kbs for use by VSATs installed at member stations; such a facility is being tested by WECB at the present time. The PBS engineering department is actively pursuing a two-way VSAT capability, but the high associated costs are not expected to come down before 1997.

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[1] Using spread spectrum and *Code Division Multiplexing*, a network could be designed which would make a video interconnect available to every person in the world on the same unique-number statistical basis as is employed currently by the international telephone system.

[2] As of this writing, Hughes requires a minimum of 50 receive sites for cost-effective operation.

[3] There are some substantial problems with SCPC carriers, including frequent drop-outs, low signal levels, and noise.

In a many-to-many low-data-rate environment where the number of endpoints exceeds approximately 50, the use of VSATs for directly linking institutions can be cost effective and convenient. It takes only a matter of days to set up the antennas and to have IDs assigned by the network operator. Although this technology is not yet suited to video instruction, many other needs which are evident during the overlay network migration phase could conceivably be met using the 128 Kbs rate. For instance, schools could interconnect their computer systems with WISCAT and WISCNET in this manner.[1]

VSAT holds much promise for the future, although its capacity is limited.

In the future, it is expected that relatively cost effective VSAT systems will be usable up to approximately 256 KBs or even DS-1 rates, which would enable instructional teleconferencing capability. Even so, it should be remembered that satellites use a limited spectrum resource and will therefore probably not be able to ultimately reach the capacity of a fiber network. Nevertheless, in the same manner as the advanced satellite techniques described above under *Future of Satellite Technology*, VSATs should be closely monitored during the migration period for application in limited capacity one-to-many or many-to-one applications where terrestrial solutions are not practical. It may be assumed that some role will be played by VSATs in the integrated statewide system of the future, if only as a result of interconnection to multi-site businesses and medical establishments.

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[1] Although the VSAT computer connection may be satisfying from a technology utilization standpoint, it is undoubtedly not cost-effective in Wisconsin, which has an extensive low-cost telephone network on the brink of providing DS-0 services to most larger communities.

3.1.5.8 Network Evaluation

3.1.5.8.1 Use in State Overlay Network

Use of Satellite technology as an element of the State Overlay Network will undoubtedly be cost effective through the planning horizon in order to directly deliver third party programs to multiple endpoints. Satellite may also be viable as a portion of the backbone delivery system during the migration phase if early resolution of fiber cost issues does not occur, and for "off loading" broadcast-type programming directly to the end user.

Satellite's best use is for delivering third-party programming to multiple endpoints.

3.1.5.8.2 Use in Regional Networks

Regional networks may wish to originate programming to be placed upon the satellite for use by intra-state and inter-state institutions. The following evaluation contemplates such use.

3.1.5.8.3 Use in Local Networks

It is anticipated that local use of satellite would primarily reflect video teleconferences and audio-interactive courses enabled through the use of a portable uplink. The following evaluation anticipates these uses.

3.1.5.8.4 Addressing Needs

Where relatively few channels are required in a broadcast mode, satellite technology could serve as a portion of backbone capacity during the migration period.

Satellite is seen as a supplemental technology in addressing the needs of distance education users.

Because difficulty in implementing the upstream aspect adversely impacts a substantial category of potential users, use of satellite must remain supplementary to other technologies, at least until wideband two-way systems are available.

Satellite use can be effective for delivery of staff development and training programs.

Rating in the Local Loop = 2.0

Rating for the Regional Network = 2.0

Rating for the Overlay Network = 2.0

3.1.5.8.5 Advantages, Disadvantages, Benefits and Risks

The use of satellite technology for direct delivery of third-party programming to the end user is cost-effective and well demonstrated in Wisconsin.

The primary disadvantages of the satellite option for backbone complete circuit use include the relatively high cost per video channel, and the general scarcity of direct access to an uplink facility. For applications requiring upstream video, especially full-motion video, a means must be found to connect the end user with a centrally located uplink. In many cases, the necessity of this upstream link involves the use of technology which itself could be adapted for two-way transmission, thereby substantially negating the advantage of the two-way video satellite distribution system (see discussion above under Section 3.1.5.3.2 - *The Two-Way Issue*).

Rating in the Local Loop = 3.0

Rating for the Regional Network = 3.0

Rating for the Overlay Network = 3.0

3.1.5.8.6 Cost Considerations

While downlinks cost about $5,000, full-sized uplinks are much more expensive, and can cost $400,000 to $750,000.

On the downstream leg of an extensive and widely dispersed video/data/voice network, the satellite option is unsurpassed for a relatively moderate number of channels to be transported. Since the transportation link is also the "last mile" system, there are no local loop costs other than the installation of a downlink which can be as inexpensive as $5,000. On the other hand, full-sized uplinks are relatively expensive at approximately $400,000 to $750,000, and must be coordinated and licensed by the FCC.

A recent innovation is the small aperture video uplink, which can use portions of a transponder called *Single Channel per Carrier* (SCPC). Typically these are 3.5 meter dishes which may either be permanently installed or mounted on a trailer and used where required. A permanent installation can cost under $50,000, while a trailer-mounted facility would cost approximately $90,000.

Satellite time can be purchased at rates which vary according to the time of day and the desired level of protection (in case of equipment failure).

As mentioned previously, time may be rented on a satellite, or entire transponders may be purchased or rented. Brokered occasional satellite time for video purposes can cost from $200 to $500 per hour depending on the satellite used and the time slot. Recurring time must be individually negotiated, subject to the type of reliability desired:

- Preemptable service - the time slot is not guaranteed if the time is required by higher classes of users.
- Non-protected service - the time slot is guaranteed unless a hardware failure occurs in the satellite network system.

- Protected service - the time slot is fully guaranteed but repointing of downlinks may be necessary if a hardware failure occurs.

Today's VSATs can be installed at relatively reasonable prices (approximately $20,000 to $25,000), but there is a monthly charge based both upon network connection costs and the amount of transponder time used (approximately $200 to $400 per month per site for 50 sites).

In order to implement the VSAT solution, the user must join a *VSAT Network*, which is managed by a *Hub Station* facility. Monthly costs are then assigned based upon TDMA usage of the network.

Rating in the Local Loop = 3.0

Rating for the Regional Network = 3.0

Rating for the Overlay Network = 3.0

3.1.5.8.7 Migration and Implementation Issues

Satellite systems do not migrate to terrestrial networks well. Use of satellite is likely to be established as an auxiliary service, and to remain non-integrated through the planning horizon. It is expected to be an effective subsystem within the technology mix nonetheless.

Satellite does not migrate to other technologies easily.

Rating in the Local Loop = 2.0

Rating for the Regional Network = 2.0

Rating for the Overlay Network = 2.0

3.1.5.8.8 Rating Total

The total evaluation numeric for the Satellite option, obtained by adding the above evaluations together, is as follows:

Rating in the Local Loop = 10.0

Rating for the Regional Network = 10.0

Rating for the Overlay Network = 10.0

3.1.6 Detailed Technology Analysis: The Public Telephone System

The public telephone network represents the second technology type discussed in this chapter, namely, a *technology system*. The telephone companies may use many core technologies in order to establish their network routes including fiber, coaxial cable, microwave and satellite. The telephone network can be viewed as an enormous omnipresent oligarchy, potentially exhibiting nearly limitless capacity. Unfortunately, there have been hampering forces, both internal and external, which prevent it from reaching its ultimate potential in Wisconsin.

3.1.6.1 Discussion

3.1.6.1.1 Carrier Types

Telephone system services are provided locally by Local Exchange Carriers (LECs) and non-locally by Inter-exchange Carriers (IXCs).

Nearly all distance education systems in use today rely to some extent upon the existing telephone network provided by regulated common carriers. Telephone-type services fall into two basic categories:

- The *Local Exchange Carrier (LEC)*: The LEC provides service *within* and confined to the four primary LATA regions of the state. Examples of LECs are Ameritech's Wisconsin Bell unit and the numerous independent telephone companies in Wisconsin.
- The *Inter-Exchange Carrier (IXC)*: The IXC provides service across LATA boundaries and connections to the national long distance network. Examples of IXCs are AT&T, MCI, and Sprint.

IXCs therefore provide the inter-LATA transportation service while LECs supply the local loop from the IXC *Point of Presence (POP)*.

Carriers are regulated by the FCC and the PSC.

Telephone carriers are regulated by the FCC and the Wisconsin Public Service Commission (PSC). Because of PSC policies which require full compensation to the utilities by those users proposing new routes for wide-bandwidth services, the use of telephone carriers for the establishment of new video routes has been relatively expensive in the past.

3.1.6.1.2 Modes of Service

Telephone services may be obtained primarily in two ways:

Dedicated lines are leased for a fixed monthly fee.

Dedicated lines: Dedicated telephone circuits are usually leased for a period of one to seven years. The dedicated capacity is assigned to the user and a fixed amount is billed monthly, whether the capacity is being used or not. Separate bills are received from the LEC and the IXC as appropriate. The monthly billing consists of two components:

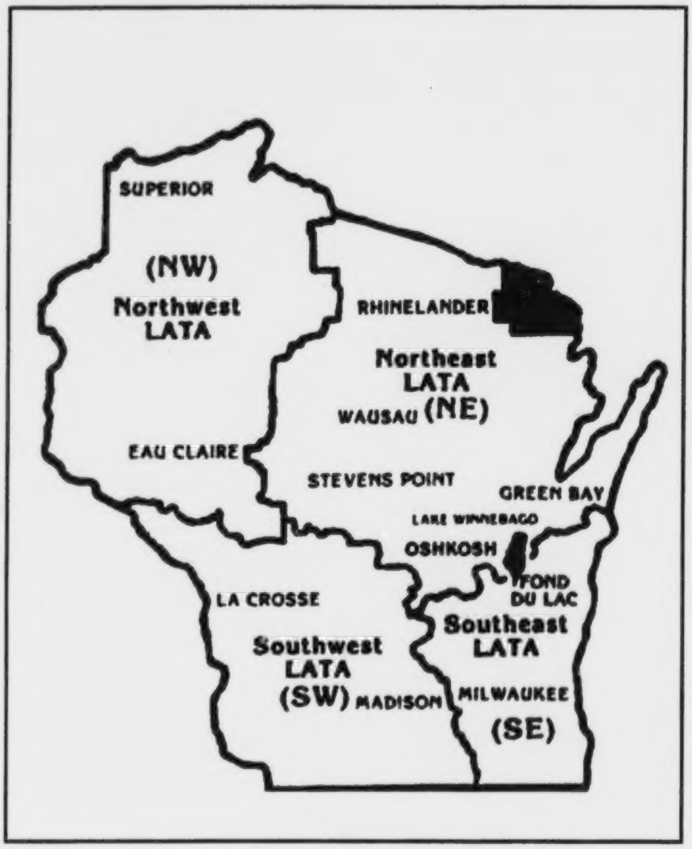
SUPERIOR
(NW)
Northwest
LATA
EAU CLAIRE
RHINELANDER
Northeast
LATA
WAUSAU (NE)
STEVENS POINT
GREEN BAY
LAKE WINNEBAGO
OSHKOSH
FOND
DU LAC
LA CROSSE
Southwest
LATA
(SW) MADISON
Southeast
LATA
MILWAUKEE
(SE)

Figure 3-1: Wisconsin LATA Boundaries

- The *Access Charge*: The access charge is the incremental cost assigned to the user to interface with the telephone system.
- *Line Charge*: Line charges are the fees charged to the user for exclusive rights to a line connecting the user premises to the telephone system.

Switched Circuits or non-dedicated lines: The standard voice grade line used by every desktop telephone is a switched line. Since more than one user can share the same equipment, the cost for switched service can be proportionately lower, and is generally usage sensitive. To date, however, the savings for switched DS-1s and DS-3s, where available, have been small because of the difficulty associated with finding shared users.

Switched lines are billed according to the amount of use.

Switched services are subject to access charges, as well as the LEC/IXC dichotomy. Therefore, the access portion of the monthly bill would be fixed, while the line charges would only apply when the line was being used.

FCC deregulation promises to lower costs through increased competition.

3.1.6.1.3 Telephone Deregulation

Over the last two years, the FCC has reworked its regulations permitting the telephone companies to carry Cable TV programming under certain conditions. Because of the potential competition, many Cable TV companies are improving their distribution plant at the same time that local telephone companies are starting to offer video services. The net result over the next 10 years or so will be a healthy competitive environment for the last mile, which will drastically reduce prices for the local loops as new routes are established. This process will proceed even faster if financial incentives are provided to the educational institutions in the form of state or vendor grants.[1]

At the present time, most of the last-mile equipment employed by the LECs operates in an analog mode. For the first phase of local video distribution network construction it can be expected that switched digital capability will continue to be scarce and relatively expensive in Wisconsin.

3.1.6.2 Capacity

Smaller bandwidth lines (e.g. for voice traffic) are readily available; circuits like DS-3s are still relatively rare and expensive.

The present capacity of the switched Wisconsin telephone network, when considered on an end-to-end basis, is geared to providing voice-grade lines at all locations and DS-1s at certain high-traffic locations. For the short term, most distance education wide-bandwidth requirements are considered to be special requests, requiring substantial lead times and a relatively large investment. DS-4s and wider bandwidths are virtually unavailable from Wisconsin telephone companies at the present time. While the voice-grade telephone system is easily obtained and cost effective for many tasks, obtaining switched services becomes progressively more difficult at higher transfer rates because the larger bandwidths begin to represent a significant fraction of the basic vendor trunking capacity. To appreciate the problem from the vendor's point of view, a telephone company may prefer to sell 24 voice circuits at an average of $40 each per month than one DS-1 at $500 per month as a single circuit which could carry four teleconferences or 24 medium-speed data channels on demand. This reluctance is only logical since the voice traffic is reasonably high and is predictable, while demand for DS-1s is much lower and more volatile.[2] Another consideration is the fact that higher-capacity switches are scarce in the last mile loop.

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1. Ameritech's **Wisconsin Plan**, which would provide no-cost fiber to the curb, may well be the first step in this direction. Another possibility would be to allow PSC mandated consumer refunds to be paid into a distance education segregated account.
2. Approximately 10 years from now, it is expected that sufficient demand will exist for high-bandwidth traffic to be statistically predictable, which will enable just-in-time inventory of wide-bandwidth interconnection capacity.

At the present time, DS-1s are available primarily on a leased basis for which the providers can be guaranteed a return on their investment, although the lease times for some high-traffic routes can be as short as one month. Capacity for dedicated DS-1s is generally available in most larger communities, such as Milwaukee, Madison, Green Bay, Stevens Point, Wausau, Wisconsin Rapids, Racine, Kenosha, Janesville, La Crosse, Appleton, Oshkosh, Fond du Lac and Eau Claire. DS-0s are somewhat harder to find, being limited primarily to southeastern Wisconsin. DS-3s can be installed on a fully-priced basis almost anywhere in Wisconsin.

As a harbinger of things to come, however, some vendors are providing a service in a few Wisconsin communities known as *Switched-56.*[1] Upon paying an initial connection and a monthly service fee, these circuits are continuously available to the customer and usage is priced on a demand basis. These circuits can be cascaded ("reverse multiplexed") to provide a combined capacity of 112 KBs, 224 KBs or even higher rates, which could enable video teleconferencing and even two-way instructional services. Although cascading circuits is expensive at the present time (because of both the cost of the lines and the combining equipment required), it represents the first step on the way to a true "video dial tone" telecommunications system.

Some types of circuits, such as "Switched-56", are available on a demand-billing basis.

3.1.6.3 Maintenance

Maintenance of telephone equipment is confined to the customer premises. New digital equipment is generally not serviceable by any but the most sophisticated users; it is therefore essential that maintenance contracts be purchased for new digital telephone and wideband service systems.

Sophisticated digital equipment requires that the user purchase maintenance contracts.

3.1.6.4 Wisconsin Telephone Resources

The vast switched connectivity represented by the Wisconsin telephone system is extremely cost effective for voice-grade demand services such as low-speed data transfer (9600 baud or less), Group 3 FAX and entry-level audiographics. These services are available in all practical multiples to nearly every business and home in the state, with the exception of some locations on Indian Reservation land.

As mentioned previously, "Switched-56" (DS-0) circuits are generally available or soon will be available for most locations near major cities, although they are still somewhat expensive. Access Wisconsin reports that approximately 75% of Wisconsin's communities will have access to fiber by the end of 1993.

Circuits for low speed applications such as voice and data are readily available and cost effective.

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[1] *Switched-56* is expected to be readily available in Milwaukee, Madison, Green Bay, Appleton, Racine, Kenosha, Eau Claire and La Crosse within the next five years.

Many existing audio and data networks are based on the use of public telephone system facilities.

Audio-only telephone-based systems currently in use for distance education include the Educational Teleconference Network (ETN), the CESA Teleconference Network (CTN) and the WisLine network. The public telephone system is also used for the WISCNET and CENTERSNET educational data services. The telephone system also plays a crucial role in upstream communications for ITFS facilities.

3.1.6.5 Future of Telephone Technology

In addition to the current voice applications already in use, the Needs Survey reveals that instructional and informational data networks using the public voice grade telephone system will continue to improve and expand. The present users of ETN and WISLINE will undoubtedly incorporate audio-graphics and video-graphics as equipment for these services becomes more available.

It is envisioned that use of the telephone system in distance education networks will continue and expand.

In the near term, telephone systems will continue to be used as upstream audio links for satellite and ITFS full-motion video applications. As two-way interactive video technology becomes dominant, data and voice communications facilities should merge with video to become image-based multimedia systems, which would be digitally transmitted over a common interconnect. In this manner, the needs of *ALL* networks could be incorporated as a single highway multi-agency solution. For instance, once WISCNET is available as a service on the common backbone, the current node charge of approximately $15,000 per year could be substantially reduced.

It is expected that ubiquitous, switched wide-bandwidth capacity to the curb will be available at the DS-3 level (or equivalent) by the year 2010, except perhaps at a scattered set of remote locations primarily in northeastern Wisconsin. This capability will not be provided exclusively by those companies generally perceived to comprise the existing telephone network (such as AT&T, Ameritech, MCI, Sprint, and the other "Baby Bells"), but by some cable companies (such as TCI) and some newcomers (such as Cable and Wireless Communications, Inc.). Because of the plethora of suppliers and services, there will undoubtedly be a short period of confusion until approximately the year 2015, when full integration of all carriers should exist under SONET and CCS-7 standards.

3.1.6.6 Special Considerations for System Integrators

The telephone system integrator is a special class of *Value Added Reseller* owing allegiance to no single electronic transportation vendor.

The telephone VAR can theoretically select the most appropriate vendor for each leg of a network. Because the VAR possesses the requisite technical expertise, they are able to negotiate favorable terms for video, data and voice transportation on a continuing basis.

The most significant VAR in Wisconsin is DOA/BITM, which continually tunes and expands the STS and CDN networks.

System integrators such as DOA/BITM can often obtain better prices by employing the resources of multiple vendors.

3.1.6.7 Network Evaluation

3.1.6.7.1 Use in State Overlay Network

Telephone System vendors will undoubtedly represent a substantial component of the ultimate State Overlay Network. In addition, the network migration plan will certainly make extensive use of the public telephone system. Whether the Telephone Companies are engaged by a super-consortium committee or by a system integrator, their use should be cost effective through the planning horizon.

3.1.6.7.2 Use in Regional Networks

Regional networks can also make effective use of Telephone System technology to originate and receive programming carried on the overlay network. The following evaluation contemplates such use.

Use of the telephone system is envisioned for the overlay, regional, and local networks.

3.1.6.7.3 Use in Local Networks

It is anticipated that local use of Telephone System technology will be extensive during both the migration period and as a component in the final network. Initially, last miles uses may well reflect analog technology which would migrate to digital techniques in the future. If local telephone companies were willing to make alliances with local cable companies and unregulated microwave suppliers, many of the last mile telco cost obstacles would disappear.

3.1.6.7.4 Addressing Needs

Telephone System technology potentially can address all video, data and voice needs rated as most important by users at the local, regional and overlay network levels. Assuming that local Telephone Companies keep pace with technology, nearly infinite expandability is possible. As initial users absorb the construction costs, educational use of fiber-based telephone transportation can supplant interim technologies such as microwave and ITFS whenever the change-over becomes cost effective.

The telephone system has the potential to meet all identified needs.

Evaluation of the telephone vendors depends upon the core technologies they employ. However, since nearly all Telephone Companies are using fiber as their future core technology, they will be evaluated as such.

Telephone System use can be effective for delivery of staff development and training programs either on a scheduled basis or on a demand basis.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 4.0

Rating for the Overlay Network = 4.0

3.1.6.7.5 Advantages, Disadvantages, Benefits and Risks

Most evolving and future standards such as ISDN and SONET specifically address telephone company usage. Funding considerations aside, telephone system technology has the capability to truly bring equality of educational access throughout Wisconsin.

The adoption of new technology is usually driven by user demand.

Although telephone utilities are generally committed to the SONET concept, they are not generally ready to rush out and purchase SONET terminals and ATM switches on a wholesale basis. Rather, most telephone companies are beginning to specify SONET compliant terminal equipment at the time of routine system upgrades. SONET implementation will likely reflect a phased activation schedule occurring over the next 5 to 10 years, lagging somewhat behind the demand for SONET based services. It is most likely that SONET will develop geographically as the demand dictates, beginning with private network applications (for instance, the ERVING system). As of today, only the optical interface standards for SONET have been set. This does not mean, however, that a SONET terminal made by one vendor will be compatible with another. Even though this is one of the primary benefits of SONET, end-to-end compatibility will not happen until the standards and software that govern alarms, maintenance, testing and network management are fully defined. Many of the vendors contacted for this study expect that all important SONET standards will be defined before the end of 1993.

New PSC regulations for allocating costs of new wideband routes are required to make networks more cost effective.

Effective use of Telephone System technology requires that the Wisconsin Public Service Commission continue to revamp its procedures for allocating the costs of new wide-bandwidth routes to educational entities. A simplified procedure which allows some anticipation of future demand would be ideal, similar to reforms enacted in Michigan and Tennessee.[1]

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[1] Lack of suitable PSC reforms could cause a major share of distance education dollars to be diverted to the unregulated carriers, resulting in a somewhat more inefficient and insufficient network. Higher long term costs would result because of the fact that the unregulated carriers in general only interconnect endpoints which exhibit a high traffic level. This would bypass many of the required rural node sites. On the other hand, the recent adoption of the *Incremental Fiber Pricing Structure* by the PSC is an important step in the direction of encouraging new distance education networks.

A declaratory ruling is required from the FCC in order to clarify the applicability of tariffs to the portions of the proposed network which would feed ITFS facilities and the state educational TV and FM networks. Up to the present time, Wisconsin Bell has appeared to be reluctant to pursue such a ruling.

The primary disadvantage of the telephone company option for regional or overlay use in wide- bandwidth applications is the relatively high cost per video channel. In many applications, two channels cost 50% to 85% of the first channel price, which compares unfavorably with some other technologies. New users on systems which have been planned and paid for by others are generally not required to pay back a portion of the pioneering costs.

Today, video channels are still very expensive and must be leased.

Since the only practical method of obtaining telephone service is via leasing, REA and NTIA grants are more difficult to obtain for this system component compared to technologies which involve capital equipment.

Most major grant providers do not like their money to be used for lease payments.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 4.0

Rating for the Overlay Network = 4.0

3.1.6.7.6 Service Costs

Costs for the various capacities of telephone lines are highly variable but are generally distance sensitive. DS-0 lines, where available, can cost $200 to $500 to install and $100 to $200 per month for local usage. DS-1 lines can cost $1,500 to $8,000 to install and $500 to $7,000 per month or more based upon distance. Some recent experiments in usage-sensitive service of DS-0 circuits have been conducted by some of the IXCs. Availability of switched DS-1 circuits is nearly non-existent in Wisconsin because sufficiently low costs cannot be negotiated by local businesses or schools.

Costs are highly variable but basically relate to distance.

Special rates are often provided for bundled services such as combinations of 36 Mbs video circuits and DS-1s ("overhead DS-1s"). Some vendors also provide "protocol translation" services where the standards of the codec being used by the caller are translated to the standards being used by the recipient, thereby reducing codec replacement costs.

It should not be overlooked that the State of Wisconsin itself, as DOA/BITM, can provide dedicated DS-1 and occasional use fractional DS-1 service at competitive rates just as can any other vendor.

The costs for DS-3 circuits provided by the telephone company vendors are the most unpredictable of all. The cost depends to a large extent upon the number of users, the capacity of in-place terminal equipment, and the extent of transportation media which is available for use. The cost also reflects the manner in which the service is offered, namely, as video transportation or as access to the "high-cap" DS-3 multiplexer port. The cost for DS-3s is distance sensitive but generally settles in at $1,500 to $2,500 per channel per month per school in a mid-sized regional network.

For the most part, the telephone carriers use fiber to transmit DS-3s. In spite of the fact that pricing procedures are fixed by regulators, differences in installed capacity allow some providers to offer better prices than others on certain routes, a fact which can be obscured if vendor-driven designs are permitted or if the subject network is not rigidly defined.

Frequently, a technology mix results in the best interim or migratory solution because of the extreme dichotomy in fiber-based wide-bandwidth costs. If, for instance, the system designer uses microwave technology for those portions of a new fiber based network which would be relatively high cost if purchased from telephone vendors, the margin between affordability and non-affordability can frequently be breached.

3.1.6.7.7 Local Equipment Costs

Many educational institutions are making a substantial effort to acquaint their telephone acquisition people with the necessity of considering future distance education technologies and telecomputing requirements when purchasing a new Key Service Unit, PBX or local hybrid switch. The degree of system expandability, conformance with emerging standards (such as ISDN), and the ability to utilize direct digital services *at the desktop* are critical. Wiring should be Level 5 and fiber, in order to allow orderly future migration.

A substantial investment is required in order to implement new local switches, on the order of $80,000 per 100 phones including voice mail, call accounting and channel service units for DS-1 access.

Rating in the Local Loop = 3.0

Rating for the Regional Network = 3.0

Rating for the Overlay Network = 3.0

3.1.6.7.8 Migration and Implementation Issues

Use of the Wisconsin telephone vendors makes excellent use of the state's existing telecommunications resources. Overbuilding should be minimal, and primarily confined to the local networks where local Cable TV systems may or may not be employed as part of the network.

Employing the telephone system makes excellent use of existing resources.

Telephone system usage should result in the maximum degree of user transparency, both with respect to maintenance and with respect to operator usage.

At the present time, the experience of educational institutions in Wisconsin is that the Telephone Companies appear to discourage the use of "high-cap" DS-3s by subscribers wishing to allocate their own services. Standard rates will have to be established for such usage so that users can be "plugged in" to future capacity expansion.

Rating in the Local Loop = 4.0

Rating for the Regional Network = 4.0

Rating for the Overlay Network = 4.0

3.1.6.7.9 Ratings Total

The total evaluation numeric for the Telephone System option, obtained by adding the above evaluations together, is as follows:

Rating in the Local Loop = 15.0

Rating for the Regional Network = 15.0

Rating for the Overlay Network = 15.0

3.1.7 Detailed Technology Analysis: Cable TV

Cable TV is a *system technology* which is only slightly less ubiquitous than the telephone system in Wisconsin.

Cable TV providers may use one or more of several technologies in the offering of their services.

Cable TV companies use several different core technologies in hooking up their customers, including coaxial cable, fiber and microwave, although analog coaxial cable is the primary transportation medium. For any given route, the capabilities of the cable network depend upon the propagation media used, as well as the type of terminal equipment employed. For the purposes of this document, it is the "in-place network" of the cable system's interconnect wiring, switches and distribution amplifiers which forms the technology *system* represented by the cable TV technology alternative.

3.1.7.1 Description

Cable Television began in the early 1960's as a means of bringing over-the-air TV broadcast signals to communities which were either too far from major cities to receive them, or which were isolated by mountain ranges. "Master Antennas" were installed on towers at elevated locations, and TV stations were brought in from as far away as 120 miles. The service was provided to individual subscribers through a distribution system utilizing primarily coaxial cable, which remains the dominant delivery technology to this day. This cable was either placed upon electric company utility poles, or if a lease agreement could not be obtained, was placed on the cable company's own poles using the public right-of-way. Subsequently, some cable television companies have used other technologies such as microwave, satellite and fiber optics to improve service to their customers.

Most cable systems today use coaxial cable in analog mode, although many systems are migrating to analog and digital fiber.

Cable TV today principally uses analog transmission techniques and most companies attempt to adhere to the EIA RS-250B standards for video broadcast. This means that the quality of the signals are expected to be Level 2 (broadcast resolution), rather than "closed circuit" or "ITFS" resolution (Level 3). The implications of the RS-250B standard are primarily the higher costs associated with signal processing equipment. In practice however, many if not most cable systems provide a product which is closer to Level 3 in resolution than it is to Level 2 because of cascaded noise. However, as cable operators upgrade their facilities and migrate to fiber optic cable as well as digital signalling standards the quality of the final product is expected to continually improve.

Cable is best suited to local applications with many endpoints.

Cable TV is a mature technology, and lends itself well to local applications. For distance education purposes, Cable TV is best suited for serving multiple locations within an urban setting. It is not particularly well suited for wide-area network applications in its present incarnation because of the quality problems associated with analog coaxial cable. In addition, management of a network which utilizes several different private companies with their associated technical and administrative interfaces would be a daunting task to say the least.

Use of local cable television systems for local and regional distance education purposes is already well established at many locations throughout Wisconsin. An educational/cable TV partnership is usually accomplished by means of a lease agreement, whereby an institution or district receives exclusive access to one or more downstream channels. Frequently, preferential rates are applied, but in any case the costs are usually low enough to allow the school programming structure to develop at a natural pace.[1] In many communities, cable TV service to the local schools is a condition of the cable company's municipal franchise agreement.

Use of cable TV in distance education systems is common in Wisconsin.

In order to utilize the cable resource, the educational institution provides the programming either live or on tape according to a schedule which fits its requirements. The means by which the programming is delivered to the cable head end are varied, ranging from the use of bidirectional cable (such as is used by the Trempealeau Valley Cooperative) to microwave (as is used by the Milwaukee Public Schools) to the physical delivery of tapes and other materials.

Programming may be live or taped.

Many cable systems in larger metropolitan areas have the capability to allow viewers to select programming, respond to surveys or order merchandise through their cable interface tuner box. Most of these systems are based upon in-band signalling technology pioneered by Warner with CUBE and Zenith with its Z-Tec concept. More frequently, a telephone line is used in conjunction with the cable channel to provide audio or low-speed data interactivity. Both of these interactive techniques have been employed in the past to provide direct-to-the-home education, but these efforts have been met with mixed results primarily because the potential audience had not been thoroughly qualified.

On some systems, users have the ability to interact (respond) to the originator.

3.1.7.2 Capacity

There are significant differences in cable TV capacity within communities throughout Wisconsin depending upon when the system was installed, and the schedule of future uses anticipated during the initial design. It can be expensive to increase system capacity beyond the design limit, since many amplifiers, taps and cables may have to be replaced and/or relocated.[2]

Cable TV capacity is highly variable among different systems

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[1] The allowance of sufficient time for a school or district to develop uses for distance education technologies is crucial. High costs create a constant pressure to utilize the educational channel to its fullest potential, leading to failures and frustration. Experience has shown that at the grass roots level, new technologies are accepted slowly at first and then grow exponentially as new applications are discovered.

[2] Most cable systems use rather disadvantageous "buss" or "branch and tree" topologies.

Channel capacities run the gamut from the twin-cable 100 channel system designed by Viacom and managed by Warner for the northern Milwaukee suburbs to the 12 channel systems used in many smaller communities. In general, most cable TV facilities utilize all of their readily accessible channels, or at least assign their non-entertainment capability to occasional use functions such as government or public access. Obtaining single-channel access for school purposes in cases where such channels are not written into the franchise agreement can be difficult, but it is generally possible for persistent local schools to obtain intermittent use of a cable channel on all but the most limited-capacity cable systems. With one or two large system exceptions, multi-channel and two-way access usually can only be obtained at franchise renewal time.

For new cable TV systems, the practical maximum number of full NTSC video channels is approximately 120, with some room left for local AM and FM broadcast and a few voice and data circuits. Although digital transmission technology is available to cable companies, most Wisconsin systems use analog transmission and frequency division multiplexing in order to keep costs low.

3.1.7.3 Implementation Considerations

Using cable for last-mile delivery can be very cost effective.

Employing analog cable TV as the last-mile connection can be extremely cost effective for the short and mid term, in spite of the fact that analog-to-digital conversions must be performed on the IXC systems or on the proposed Wisconsin overlay network. Although the digital codec must usually be located off of the school premises, the resulting simplicity of operation usually offsets the loss in flexibility for most start-up distance education systems.

Two-way video is technically possible but not generally available.

As previously mentioned, demand-basis two-way video is generally not available on any but the largest cable TV systems. However, even fairly small cable systems can and have installed two-way cable to network district schools under special contract (i.e. the Whitehall Cable system). Bridging the two-way gap between the schools and the cable subscriber (for learn-at-home applications, for instance) has been generally non-viable in Wisconsin.

Institutions and consortia using the cable TV method of delivery should maintain a close liaison with their company representatives as well as the local telephone companies in order to be in a position to migrate to a full digital network in the future (currently estimated as the year 2010 to 2015, which should be well after the cost of the initial analog investment is recouped). Local schools may be in a much better position to negotiate services at franchise renewal time.

The majority of cable systems, especially those outside of the Milwaukee/Madison/Appleton/Green Bay corridor, do not employ a significant number of upstream channels. The educational institution wishing to employ a cable TV provider must therefore utilize a separate route to reach the cable studio or *head end*, where the signal can be distributed downstream throughout the community. Frequently, this separate route is provided by the cable company using a separate coaxial cable. In other cases, a microwave link is used.

3.1.7.4 Maintenance

On the average, the reliability record of cable companies has been below that obtainable by other means. There is virtually no route redundancy and repairs frequently take many days. Many educational entities also find that their technical and maintenance requirements are not high on the cable TV operator's priority list. On distressingly many systems, outages are fairly frequent because of a lack of back-up pole-mounted power supplies. In contrast to telephone company technicians, many cable-TV service technicians feel free to test transmission systems during the day, thereby disrupting programming.

Cable companies tend to have below average reliability records.

The above scenarios can result in maintenance being a thorny issue with respect to some cable TV systems. Very few cable companies maintain engineering-level staff personnel; rather, reliance is placed upon the expertise of the installers. The installers are generally not equipped to deal with complex system problems such as intermodulation (interference to one signal on the cable caused by another) ghosting (a loss of resolution due to double images originating as cable echoes) or differential phase and gain (loss of detail and color smearing).

Another difficult area relates to the restoration priority which is usually assigned to the educational channels on a cable TV system. After a wide-area outage, such as can occur during a lightning storm, the service to the educational institutions might be reestablished only after the traditional subscribers are restored. It should be noted that cable outages are a rather more frequent event than either broadcast television or telephone service disruptions, so that restoral issues should be specifically considered when an agreement is signed. For the same reason, care should be used in assigning life safety services to cable TV.

Although cases of egregious maintenance lapses are becoming steadily less prevalent in Wisconsin, the ability to meet these maintenance concerns should be spelled out in advance of signing a contract with a cable TV system to carry high-priority video programming.

On the positive side, the majority of equipment located at the schools which provide the cable interconnect is very familiar to educational staff. The operation of VCRs and TV sets is little different than that used in the home. When one of the many responsible and responsive cable companies is employed for local video transportation, a user-friendly and cost-effective system generally results.

User on-site equipment such as TVs and cable boxes tend to be familiar to user staff, thus making such systems easier to operate.

3.1.7.5 Wisconsin Cable Resources

Nearly every incorporated community in Wisconsin is within the reach of a cable system. It is a ubiquitous resource second only to the telephone system, and should definitely be considered as part of the local system technology mix if reliability and two-way issues are addressed.

Cable service is readily available throughout the state. However, two-way capability may require the upgrade of a system's facilities.

With a few notable exceptions, cable systems are usually confined to urban and near-urban locations served by a single cable operator. The use of channels for two-way interactive video by schools usually requires individual negotiation with the cable operator. If sufficient channels are not available, the schools may have to wait until the cable operator upgrades its facilities or negotiates the construction of additional facilities at a specified cost. Most cable operators appear willing to work with schools if facilities and funds allow. However, respondents to the needs surveys showed a wide range of cooperation levels (from excellent to abysmal) evident in dealing with their local cable provider.

3.1.7.6 Future of Cable Technology

Partly because of competition from the telephone companies, most cable TV companies are actively making plans to upgrade their services by:

- Expanding the number of channels available on older systems.
- Improving quality and reliability (some systems employ special *pilot* signals on the cable which are used to make automatic level adjustments).
- Employing wireless cable technology such as the CARS microwave band or MMDS services to deliver signals to low density areas economically.
- Installing higher capability decoder boxes.
- Adding light fiber routes to increase capacity and improve quality.

Future plans promise more channels and greater reliability.

Rather lower on today's upgrade list are services which will be required at the next major cable introspection point, such as:

- Enabling extensive two-way capability.
- Carrying full digital services.

The key to making the Wisconsin distance education system conform to the plans of cable companies is to maintain open lines of communications at all times. It is critical that local educational institutions and consortia be involved during the franchise renewal process, so that their concerns can be heard by cable personnel and municipal authorities alike. A local cable company not responding to educational needs can be replaced by local telephone companies as the vendor of choice.

A list of cable TV companies in Wisconsin is included as part of the electronic database associated with this document.

Local users should make their needs known when a cable system's franchise comes up for renewal.

3.1.7.7 Network Evaluation

3.1.7.7.1 Use in State Overlay Network

Use of cable TV providers as part of the State Overlay Network is not recommended.

3.1.7.7.2 Use in Regional Networks

Use of cable TV providers in the regional networks is recommended only if maintenance and quality concerns inherent to wide-area cable systems are adequately addressed. Under such conditions, the following evaluation under *Local Networks* would apply to Regional Networks as well.

3.1.7.7.3 Use in Local Networks

It is anticipated that the primary use of cable TV will be at the local network level; the following evaluation will therefore be confined to the local loop.

Cable TV use is envisioned mainly at the local network level.

3.1.7.7.4 Addressing Needs

Properly engineered and maintained cable systems could economically serve concentrations of schools within Wisconsin communities. Coupled with digital fiber systems that interconnect individual communities or school districts in regional networks, the cable companies could serve a niche within the statewide distance education system from the present time through the planning horizon.

However, it is likely that telephone utilities will also begin offering low cost analog systems[1] if competition warrants, providing a choice for educational consumers based on service and costs. Some of the smaller cable companies will not be able to compete with the telephone companies, especially with respect to migration toward SONET and other digital standards. In Michigan, the telephone companies are currently competing with the cable operators for the local loop distance education business. Such competition makes both methods more responsive to the needs of the educational institutions, but also places a burden upon the local network designer to fully ascertain the cable company's present capabilities and future plans.

Properly engineered and maintained systems have the capability to meet local needs.

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[1] Regulated vendors may be placed at a disadvantage in supplying analog services, however, because PSC regulations require a larger cost to be charged for transportation compared to digital services.

On the other hand, many older cable systems do not have the capacity to add a new educational channel and are therefore not willing to give up scarce space on the cable unless the school district pays the costs of a system-wide upgrade. In such cases, the costs of upgrading make the cable TV option non-viable.

The analog cable TV option requires the use of full-motion video channels for use in staff development and teleconferencing, since reduced-bandwidth digital compression is generally not available.

Rating in the Local Loop = 4.0

3.1.7.7.5 Advantages, Disadvantages, Benefits and Risks

In last mile applications, the low cost and utility advantages of the analog coaxial cable used by cable companies can enable the carriage of a sufficient number of channels so as to make the immediate revolutionary change to fiber optics unnecessary in the short and mid term. However, once the overlay and regional distribution network is fully digital and SONET compatible (estimated by 2005), most or all local coaxial distribution links will certainly be replaced with fiber, leaving coaxial cable to be used solely within local building wiring.

Low cost and high utility are advantages. However, cable is not well suited to voice and data applications.

Because they are primarily intended for video broadcast, cable systems do not lend themselves easily to voice and data transmission. In addition, single-cable systems have extremely limited capability for two-way video, caused by the following factors:[1]

- Data rates may be limited by dispersion distortion.
- Alternate means may be required to accomplish upstream links.
- A fully redundant system may be required.

Cable TV companies are regulated by local and federal authority, but they are generally unhampered by PSC cost recovery regulations.

Since the cable company maintains its own maintenance staff, a minimum impact upon a local institution's personnel is usually expected.

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[1] Multiplexing on single-cable systems is generally accomplished through use of mid-split or sub-split filters which seriously impacts channel capacity. On the other hand, two-cable systems (such as the Milwaukee northern suburbs *Warner* system, dedicate most of a second cable for two-way applications. If extensive user demand for these services must be accommodated by the cable TV system, some limitations will undoubtedly be evident.

Use of cable TV should generally be limited to relatively short lease terms so that alternatives can be frequently evaluated. This is especially true if the local telephone companies have near-term plans to provide digital capability.

Rating in the Local Loop = 3.0

3.1.7.7.6 Cost Considerations

Typical cable TV interconnect pricing for a single video channel is usually based on the route-mile, and averages approximately $4 per mile per month, plus a $200 to $500 per month access charge.

Installation of cable TV services can cost from $5,000 to $50,000 per institution depending upon the state of readiness of the cable TV company.

Video can be very cost effective, but voice and data solutions cannot comptete with those offered by the telephone system.

Cable is very cost effective for local video loop applications. On the other hand, the cost to add voice and data traffic is highly variable, and is generally not competitive with telephone company solutions. In addition, system reliability is not generally considered to be sufficient for these uses.

Some cable companies must provide a certain amount of free video transportation to educational entities as part of the terms of their franchise agreement. Others provide low cost access as a goodwill gesture. In any case, local institutions should be actively involved in the franchise renewal process in order to make their requirements known to the local authorities and the cable companies at the time these requirements are most likely to be addressed.

Cable migrates well to newer technologies.

Rating in the Local Loop = 5.0

3.1.7.7.7 Migration and Implementation Issues

For the most part, migration of cable facilities toward more capability and capacity is automatic and transparent to the user, since the cable company must continually upgrade their plant in order to compete with other delivery mechanisms.

The cable TV option makes good use of existing Wisconsin state resources.

Rating in the Local Loop = 4.0

3.1.7.7.8 Ratings Total

The total evaluation numeric for the cable TV option in the local loop is 16.0, obtained by adding the above evaluations together.

3.1.8 Detailed Technology Analysis: Instructional Television Fixed Service (ITFS)

This section examines the future of ITFS technology in Wisconsin.

ITFS is a core technology currently in extensive use throughout Wisconsin, but which is anticipated to be phased out shortly after the first decade following the turn of the century.

The objective of this section of the document is to explore the future role of ITFS systems in the State of Wisconsin.

This discussion will provide a technical and financial analysis of the areas within Wisconsin where ITFS should be considered as a possible alternative in order to meet local and regional distance education requirements.[1] This analysis will be based on topography, frequency availability, and the projected costs of alternative technologies. Instances where use of ITFS may be inappropriate will be identified, along with a method to measure whether or not new systems which may be proposed in the future conform to the outlined acceptability criteria.

Finally, a migration schedule will be presented suggesting a time line within which the operation of existing WECB-licensed ITFS facilities should be turned over to the system users. Guidelines will also be given to the operators of existing systems with respect to the implementation of high-capacity wide-bandwidth technologies.

3.1.8.1 Description

ITFS is a microwave-based omnidirectional broadcast technology similar to standard VHF and UHF television. ITFS uses 2.5 GHz microwave frequencies which are intended by the FCC to be reserved for use by educational institutions.

The ITFS service differs from point-to-point microwave service (described in Section 3.1.4) in that the signal is *broadcast in all directions at once* from a non-directional or *omnidirectional* antenna. This one distinction, however, makes an essential difference in the manner in which the systems are designed and used. Like broadcast television, ITFS has the advantage of being able to serve large numbers of receive locations economically, although the upstream video path (from the subscriber back to the transmit facility) is generally not so economically implemented.[2]

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[1] These requirements refer to those needs identified during the *Needs Assessment* phase of the project.

[2] This topology is usually referred to as a "one-to-many mapping."

Because of power limitations and frequency differences, ITFS has a somewhat more limited range than broadcast TV and cannot easily overcome some of the significant terrain anomalies frequently encountered in Wisconsin. At some locations, intervening hills can require that receive sites employ very tall towers in order to acquire the signal, which can quickly erase the ITFS advantage of low cost. Experience has shown that, for the average Wisconsin ITFS network, approximately 15% of the schools will require tower heights in excess of 150 feet .[1]

Because of channel availability limitations, the return segment of two-way video must generally be limited in scope, or alternative means must be found to relay the return video (such as traditional point-to-point microwave). ITFS is an inherently one-way technology.

ITFS video signals represent a somewhat lower resolution level (Level 3) than is obtainable with light fiber (Level 1), FM microwave or satellite (Level 2). Under the present technical structure, there is no provision for advanced concepts such as high-definition television.

3.1.8.2 Summary History

Although the three newest distance education systems implemented within the 1992-1993 time period have employed light fiber as the primary component, ITFS represents the dominant distance education technology used in Wisconsin at the present time. ITFS has been employed in Wisconsin by educational institutions since approximately 1970, when the Milwaukee School Board applied to the FCC for four frequencies.[2]

ITFS is the dominant distance education technology in Wisconsin currently, although newer systems tend to use fiber technology.

Subsequently, successful ITFS systems were designed and constructed in Sheboygan, Green Bay and Wausau among other communities. The projected role of ITFS in the Wisconsin distance education migration plan is presented in subsequent chapters of this document.

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[1] The cost to construct a 150' tower can be $10,000 to $20,000, depending upon soil conditions. Higher towers increase in cost as a second-order function.

[2] Although use of ITFS by the Catholic Archdiocese in Wisconsin predates even the school board applications, declining enrollment and the consolidation of facilities forced the Archdiocese to relinquish their ITFS channels in 1975. These channels were subsequently obtained by UWM and the Milwaukee Area Technical College. Recently, in a dubious cost cutting move, MPS turned off its 150+ ITFS receive sites which had been operating up to that time as the very model of a cost-effective distance education network.

ITFS has a more limited range than broadcast TV.

In 1989, the Wisconsin Legislature asked that the WECB project the cost of creating a statewide ITFS system, as well as the cost of providing a similar service using alternative technologies[1]. At that time, the cost was estimated as $10 Million for a non-interconnected system, which was more cost-effective at the time than either fiber optic cable or an exclusively satellite solution. In evident anticipation of the results of this distance education study, the ITFS project further concluded:

"The value of these ITFS systems will be enhanced significantly when they are interconnected. This should be given full consideration as the state studies the interconnection needs of other existing and planned systems.

A statewide telecommunications system needs to be established and ITFS should be an important part of that system.

Fiber optics may provide an alternative to ITFS in those areas of the state where ITFS is impractical. Fiber also has important potential as an interconnection technology, especially in a cooperative relationship with local telephone companies."

ITFS uses frequencies assigned by the FCC and reserved for use by educational institutions. Unlike microwave, ITFS broadcasts in all directions at once and thus can serve many receive sites at once.

3.1.8.3 Assigned Frequencies

The FCC has assigned five groups of four 6 MHz channels each, designated as follows:

- "A" Channels:
  - A1 = 2500-2506 MHz
  - A2 = 2512-2518 MHz
  - A3 = 2524-2530 MHz
  - A4 = 2536-2542 MHz
- "B" Channels:
  - 2506-2512 MHz
  - 2518-2524 MHz
  - 2530-2536 MHz
  - 2542-2548 MHz
- "C" Channels arranged in the same manner beginning at 2548 MHz.
- "D" Channels interleaved with "C" channels beginning at 2554 MHz.

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[1] *Instructional Television Fixed Service - a Statewide System*, January 1, 1990.

- "G" Channels arranged in the same manner beginning at 2644 MHz and interleaved with the "H" Channels assigned to the MMDS Service.
- "H" channels beginning at 2650 MHz (three channels only).

ITFS channels also have reserved frequencies to be used for a return path audio signal.

Since the ITFS channels are interleaved, care must be taken to avoid adjacent channel interference when interleaved groups are used in the same community. Generally, unless the sites are co-located, adjacent groups must be cross-polarized.

For each group of channels, the FCC has assigned four *response channels* which can be used for returning interactive audio to the central transmitter location. However, since only one audio channel is assigned to each video frequency, most ITFS systems find it more economical to use the telephone system for the return audio path (often called "upstream" audio).

However, most ITFS systems use the telephone system for return audio.

The FCC will usually permit the assignment of only one frequency group (four video channels with associated audio) at a given location to be owned by any one educational entity. An FCC application must be submitted demonstrating that the proposer is a *bona fide* educational entity and that interference is not caused to other similar systems located closer than approximately 65 miles.[1]

There are over 100 ITFS systems, studio-to-transmitter links and inter-city relays either existing or in the preliminary stages of construction in Wisconsin (see list, Appendix B-2 to B-6).

3.1.8.4 Design Considerations

Although ITFS transmitting equipment falls in the mid-range of cost effectiveness for the various video technologies, the receiving equipment is extremely low cost and becomes more cost effective as a higher number of receive points are employed. Under favorable terrain conditions, and using a transmitting antenna approximately 400 to 500 feet high, an inexpensive roof-mounted receiving antenna/converter located at each institution can provide coverage of a 20 mile radius. Such a system can deliver four to eight TV channels using a standard television set as a demodulator. These advantages make ITFS an excellent last-mile choice when channels are available and extensive use of upstream video is not required.

ITFS transmit equipment is moderately expensive ($120,000 to $150,000 per location), but receive site equipment is very inexpensive ($2,000 to $10,000 per location).

Many Wisconsin educational institutions are intimately familiar with the advantages, disadvantages and costs of ITFS, since it is in widespread use today. Numerous transmit sites have been built in Wisconsin at an approximate average cost of

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[1] Recently, a few commercial *wireless cable* (MMDS) interests have contributed to the depletion of the ITFS resource by setting up educational "figurehead owners" and using the frequencies primarily for entertainment pay TV.

$120,000 to $150,000 per location. Real world receive sites have cost approximately $2,000 to $10,000 per location depending upon the requirements for the tower structure.

One aspect of ITFS use which has made it attractive in the past is the apparent willingness of MMDS operators to partially or completely fund such systems in return for a majority share in the system use. The advantages and disadvantages of these arrangements are explored in a separate pamphlet entitled "Leasing ITFS Excess Capacity to MMDS Operators" available from the Educational Communications Board.

3.1.8.5 Wisconsin ITFS Resources

3.1.8.5.1 Existing ITFS Use in Wisconsin

ITFS is in extensive use in Wisconsin for local and regional systems.

ITFS is already in extensive use in Wisconsin for both local and regional networks. It will therefore be required that any statewide overlay network must interface with ITFS systems. This consideration aside, there are undoubtedly some locations in Wisconsin where ITFS use could be justified as an interim measure, although amortization calculations should take into account the point at which the video channel requirement exceeds the frequency allocations available, especially for two-way upstream use.

There are several ways to accomplish two-way interactivity using ITFS, although they involve constructing second parallel networks.

Although ITFS is an inherently one-way video broadcast medium, a limited two-way functionality can be established in three ways:

- Using point-to-point microwave or other alternative delivery mechanisms, the major program producers may be connected to the system for two-way video via a hub configuration similar to that described above for the satellite service. This is the arrangement used by Northcentral Technical College in Wausau. The disadvantage of this technique is that it usually is not cost effective to provide two-way video to every occasional user.
- One-way video and two-way audio can be provided to all receive sites by employing a dial-up telephone line and an audio conference bridge. This is the arrangement typically used in Wisconsin today as well as other states such as Indiana.
- In spite of the broadcast nature of ITFS, there are a few systems located throughout Wisconsin for which enterprising users have been able to install a fully interactive ITFS video network by dedicating separate ITFS frequencies to each originating institution. Although this technique is very spectrum inefficient, these systems were generally installed before contention for scarce microwave frequencies became a factor. An example of this type of two-way system is the Fox Valley Technical College network in Appleton and Oshkosh, Wisconsin.

3.1.8.5.2 Future Use Possibilities for Statewide ITFS

The ITFS option is deemed not suitable for major expansion in Wisconsin with respect to any of the three network elements for three reasons:

- The supply of frequencies is limited, even assuming future compressed video and digital multiplexing techniques are fully developed.
- At most, four 6 MHz channels can be assigned to each institution according to FCC regulations. Even with two-for-one multiplexing, a maximum of eight video slots are available for use as delivery, inter-city relay, and studio-to-transmitter links in a given geographic area. Of course, point-to-point microwave may be used to supplement these frequencies, but the primary advantage of ITFS is the relatively low cost of the AM modulation technique employed. This advantage is partially negated as higher-cost FM microwave is utilized.
- Commercial MMDS providers are scouring the State of Wisconsin signing up many educational institutions (especially high schools) which have little or no immediate interest in providing distance education services. These commercial providers then "take control" of scarce ITFS frequencies, thereby causing a net loss in distance education capability, not only for the subject institution but for all educational entities located within 50 miles.

Although ITFS is in widespread use, it is not deemed suitable for major expansion in Wisconsin due to limited capacity, limited availability of channels,and the fact that ITFS is inherently a one-way medium.

Attached as Appendix B-9 through B-11 is a complete statewide ITFS allocation study which shows the approximate area where new ITFS transmitting stations could be placed.

3.1.8.5.3 Assumptions

This ITFS allocation study is based upon the following parameters:

- All ITFS stations now in operation will eventually utilize all four channels in their assigned group.
- Frequencies assigned as STLs and ICRs will be protected as all four group frequencies within the primary station's service contour.
- New ITFS stations will be omnidirectional.
- Interference is based upon normal terrain and the following mileage separations:
  - Co-channel plane polarized = 55 mile radius
  - Co-channel cross polarized = 40 mile radius
  - Adjacent channel plane polarized = 25 mile radius
  - Adjacent channel cross polarized = 5 mile radius

3.1.8.5.4 Scope for New ITFS Allocations

Using the above assumptions, there is room in Wisconsin for 23 new ITFS facilities located approximately at or near the following communities:

1. Friendship
2. Watertown
3. Elkhorn
4. Argyle
5. Baraboo
6. Spring Green
7. Prairie du Chien
8. Readstown
9. Elroy
10. Millston
11. Blair
12. Alma
13. Spring Valley
14. Turtle Lake
15. Gilman
16. Hollister
17. Goodman
18. Lac du Flambeau
19. Webb Lake
20. Hayward
21. Washburn
22. Phillips
23. Glidden

In addition to the above installations, it would be possible to add approximately 14 additional systems throughout the state using terrain shielding and directional antennas. Most of these extra systems would only be of use in certain specialized circumstances, and in the opinion of this consultant should not be employed in the initial design of a statewide system due to a marginal cost effectiveness. In any case, some additional channels should be held in reserve for use in interconnecting other school districts or business partners.

3.1.8.5.5 Use of the Attached Allocation Charts

The attached allocation charts are for use *ONLY* within the scope of this distance education technology study. They should not be used as an assignment tool to indicate either the availability or lack of availability of ITFS frequencies at any particular location. A complete engineering study should be performed if a new ITFS assignment is desired in a given community.

3.1.8.5.6 Possible Uses of Wisconsin ITFS Capacity

The ITFS resource in Wisconsin could either be assigned a role as a primary component in a statewide distance education overlay system or as a last-mile delivery mechanism for peripheral school districts which do not have ready access to cable, satellite, or fiber.

3.1.8.5.7 Statewide ITFS System

Using the figure of 23 new ITFS systems and the $322,000 cost per system as tabulated previously yields a total cost of $7,406,000 to design and construct as many new ITFS facilities as will economically fit within the borders of Wisconsin. These ITFS systems would be interconnected with at least one other regional distance education system, (*not necessarily ITFS*).

In order to form an ITFS backbone, however, links would be required between approximately 18 existing systems. On the average, each interconnect could be assumed to cost $75,000 for the first channel and $25,000 for each of three additional channels, since some existing resources such as tower structures would undoubtedly not be in place to provide the link. Using the inter-system standard of one channel per interconnect as assumed previously, an additional $1,350,000 would be required to interconnect existing distance education systems to form the virtual backbone. This would yield a total of $8,756,000 to form the most extensive statewide ITFS system which could be economically installed. It is assumed that existing ITFS regional networks not part of the backbone system would plan to interconnect to the new statewide system on their own. Audio return could be utilized through the STS or public telephone network.

It would cost approximately $8.7 million to construct a statewide ITFS backbone providing one video channel in one direction only (i.e. not two-way).

Ultimately, a network could be formed which would deliver four video channels *downstream* to at least the following Wisconsin communities in addition to any possible subset of the communities specified under *New ITFS Allocations* (Figures in parenthesis are the approximate number of persons contained within the ITFS coverage contour):

- Appleton (150,000)
- Oshkosh (55,000)
- Sheboygan (59,000)
- Green Bay (149,000)
- Eau Claire (74,000)
- Egg Harbor (20,000)
- Irma (4,000)
- Janesville (53,000)

Ultimately, up to four video channels (one way) could be provided to the following communities:

- La Crosse (69,000)
- Madison (240,000)
- Medford (9,000)
- Milwaukee (1,270,000)
- Park Falls (4,000)
- Platteville (35,000)
- Rhinelander (27,000)
- Rice Lake (8,500)
- Superior (134,000)
- Wausau (55,000)

Such a system would serve approximately 2.2 million state residents, as well as the following school districts:

The above populations total 2,415,500. Because of overlapping coverage areas, the true population served would be approximately 2,175,000 persons. The existing ITFS network is shown in the attached Appendix B-1.

The following school districts would be served by these systems:

- Appleton

  Appleton Area School District
  Freedom Area School District
  Hortonville Area School District
  Kaukauna Area School District
  Little Chute Area School District
  Seymour Community Area School District
  Shiocton School District

- Oshkosh

  Menasha School District
  Neenah School District
  Omro School District
  Oshkosh Area School District
  Winneconne Community School District

- Sheboygan

  Cedar Grove-Belgium School District
  Elkhart Lake-Glenbeulah School District
  Howards Grove School District
  Kohler School District
  Oostburg School District
  Plymouth School District

Random Lake School District
Sheboygan Area School District
Sheboygan Falls School District

- Green Bay

Ashwaubenon School District
Denmark School District
DePere School District
Green Bay Area School District
Howard-Suamico School District
Pulaski Community School District
West DePere School District
Wrightstown Community School District

- Eau Claire

Altoona School District
Augusta School District
Eau Claire Area School District
Fall Creek School District

- Egg Harbor

Gibraltar Area School District
Sevastopol School District
Southern Door School District
Sturgeon Bay School District
Washington School District

- Irma

Merrill Area School District
Tomahawk School District

- Janesville

Beloit School District
Beloit Turner School District
Clinton Community School District
Edgerton School District
Evansville Community School District
Janesville School District
Milton School District
Parkview School District

- La Crosse

Bangor School District
Holmen School District
La Crosse School District

Onalaska School District
West Salem School District

- Madison

Belleville School District
Wisconsin Heights School District
Cambridge School District
Deerfield Community School District
Deforest Area School District
Madison Metropolitan School District
Marshall School District
McFarland School District
Middleton-Cross Plains School District
Monona Grove School District
Mount Horeb Area School District
Oregon School District
Stoughton Area School District
Sun Prairie Area School District
Verona Area School District
Waunakee Community School District

- Medford

Gilman School District
Medford Area School District
Rib Lake School District

- Milwaukee

Brown Deer School District
Cudahy School District
Fox Point J2 School District
Maple Dale-Indian Hill School District
Franklin School District
Nicolet UHS School District
Glendale-River Hills School District
Greendale School District
Greenfield School District
Milwaukee School District
Oak Creek-Franklin School District
Saint Francis School District
Shorewood School District
South Milwaukee School District
Wauwatosa School District
West Allis School District
Whitefish Bay School District

Whitnall School District

- Park Falls

  Park Falls School District
  Phillips School District
  Prentice School District

- Platteville

  Bloomington School District
  Boscobel Area School District
  Cassville School District
  Cuba City School District
  Fennimore Community School District
  Southwestern Wisconsin School District
  Lancaster Community School District
  Riverdale School District
  West Grant School District
  Platteville School District
  Potosi School District

- Rhinelander

  Minocqua J1 School District
  Lakeland UHS School District
  Rhinelander School District
  Three Lakes School District
  Woodruff J1 School District

- Rice Lake

  Barron Area School District
  Cameron School District
  Chetek School District
  Cumberland School District
  Prairie Farm School District
  Rice Lake Area School District
  Turtle Lake School District

- Superior

  Maple School District
  Solon Springs School District
  Superior School District

- Wausau

  Athens School District
  Edgar School District

Marathon City School District
Mosinee School District
D C Everest Area School District
Spencer School District
Stratford School District
Wausau School District

Additionally, the following towns and school districts could possibly receive service from new ITFS locations:

Of the previously listed *possible* locations where new ITFS systems could be placed, the following communities would be well situated both from an allocation standpoint and in the interests of equalizing educational opportunity throughout the state (populations given are the number of persons who would be served):

- Friendship (9,000 persons)
- Watertown (30,000 persons)
- Elkhorn (25,000 persons)
- Baraboo (16,000 persons)
- Prairie du Chien (5,800 persons)
- Readstown (3,700 persons)
- Lac Du Flambeau (4,000 persons)

These facilities would service persons in the following school districts:

- Friendship

Adams-Friendship Area School District

- Watertown

Fort Atkinson School District
Jefferson School District
Johnson Creek School District
Lake Mills Area School District
Palmyra-Eagle Area School District
Waterloo School District
Watertown School District

- Elkhorn

Delavan-Darien School District
East Troy Community School District
Elkhorn Area School District
Fontana J8 School District
Geneva J4 School District
Genoa City J2 School District
Lake Geneva-Genoa City School District

Lake Geneva J1 School District
Linn J4 School District
Linn J6 School District
Sharon J11 School District
Big Foot UHS School District
Walworth J1 School District
Whitewater School District
Williams Bay School District

- Baraboo

Baraboo School District
Reedsburg School District
Sauk Prairie School District
River Valley School District
Weston School District
Wisconsin Dells School District

- Prairie du Chien

North Crawford School District
Prairie du Chien Area School District
Seneca School District
Wauzeka-Steuben School District

- Readstown

DeSoto Area School District
Hillsboro School District
LaFarge School District
Kickapoo Area School District
Viroqua Area School District
Westby Area School District

- Lac du Flambeau

Boulder Junction J1 School District
Northland Pines School District
Lac du Flambeau #1 School District
Phelps School District

This recommended subset of the possible new ITFS systems would service a total of 108,500 persons. Along with the 2,175,000 persons who would be served by the existing systems, a total of 2,283,500 persons would be served out of a total Wisconsin population of 4,891,769, or 46.7%.

Constructing all of these stations would serve approximately 46.7% of the state's population.

These figures support the conclusion that ITFS technology should not be expanded for wide-area service within Wisconsin.

3.1.8.5.8 Peripheral Use of ITFS

Alternatively, ITFS could be used to supplement an overlay comprised of other technologies. A list of pending projects which are consistent with this plan are given.

As an alternative to forming a statewide ITFS system, ITFS could be reserved for use on the periphery of a backbone formed with other technologies. This would achieve the last-mile link in instances where the regional requirements are appropriate to the unique attributes of ITFS distance education systems.

The following ITFS projects have been identified which would most probably meet these criteria (the approximate cost of each project is given in parenthesis):

- Central Sands ITFS ($424,663).
- CESA 7 Door County ITFS ($458,000).
- Pharmacy Tech ($150,000).
- CESA 10 CWETN Mosinee ITFS ($184,500).
- Fox Valley Tech Interconnect ($170,000).

These projects total $1,387,163. They represent those ITFS ventures for which local commitment has been obtained and for which sources of funds are currently being sought.

It should be noted that other factors such as local budgetary constraints or the sudden availability of other technologies could cause some projects to be deleted from this list and/or others to be added.

Several other projects which are in the early stages of consideration would fit well with the proposed peripheral ITFS concept but are not sufficiently developed to include in the above tabulation:

- Moraine Park Technical College.
- CESA #7 NEWTEC ITFS Project.
- UW-Eau Claire ITFS Project.
- UW-Green Bay Upgrade.
- CESA 8 ITFS for Oconto Falls.
- UW-Platteville ITFS System.

3.1.8.6 Future of ITFS Technology

A new technology called LMDS is being considered by the FCC and must be monitored.

A new microwave omnidirectional service, called *LMDS*, is in the final stages of approval at the FCC (final comments are due by November, 1993) . LMDS uses the 28 GHz spectrum and digital modulation. As a quasi-cellular service, it would be useful as a wideband umbilical to portable and mobile receivers. At the present time, this technology is quite expensive, but it bears watching for future application as a permanent part of the statewide network as the technology matures.

3.1.8.7 Advantages, Disadvantages, Benefits and Risks

3.1.8.7.1 Advantages Of ITFS Over Other Technologies

As previously stated, ITFS technology is not recommended for use in the overlay network. For the regional and local networks, interim use is recommended in cases where extensive upstream video paths are not required. The discussion below provides a detailed discussion with respect to the proper purpose and future of ITFS as a component in the Wisconsin distance education environment.

ITFS is not recommended for use in the overlay network. For regional and local networks, use is recommended where a return video path is not required.

Use of ITFS as a distance education technology has several advantages:

- As a broadcast technology, one transmitter site can serve an unlimited number of receive sites within a radius of approximately 15 to 25 miles (depending upon terrain).
- It is very easy to add new receive sites or to disconnect sites no longer being used, since the receive sites are not connected to each other.
- After the installation of the first channel or group, additional channels can be added in the future without modification to or disruption of the existing receiving equipment in the field. For instance, in Milwaukee separate ITFS groups are utilized by the Milwaukee Area Technical College, the Veteran's Administration and the University of Wisconsin. All of these channels (up to twelve) can automatically be utilized at nearly any school, business or other location within the metro area by installing simple antenna equipment similar to a standard TV antenna.
- The transmit equipment for ITFS is relatively cost effective compared to competing technologies (see discussion and cost breakdown below).
- The receive site equipment is inexpensive and simply installed, assuming that line-of-sight exists to the transmitter site (see discussion and cost breakdown below). An inexpensive block converter is antenna mounted and a standard TV set can be used for a monitor, thereby obviating the need for specialized video display equipment.
- Costs to design and implement an ITFS system are quite reasonable (see cost discussion below).
- The complete composite video signal is transmitted via the AM microwave system, including Stereo Audio and Separate Audio Program (if used). This enables *descriptive audio* (visually impaired) programming, as well as bilingual education without the use of additional equipment. Similarly, Vertical Interval Testing (VIT), Line 19 encoding and/or Vertical Interval

Among ITFS advantages are low cost per site, easy expandability, and relatively simple equipment needs.

Signaling (VIS) can be used for closed captioning and other services without incurring additional cost in the transmitting and receiving equipment.

- ITFS technology is well understood and local technicians can be readily trained to maintain the equipment.
- If frequencies are available, local systems are easily and economically interconnected via ITFS Studio-to-Transmitter Links (STLs) and Inter-City Relays (ICRs) which can span paths of over 35 miles.

3.1.8.7.2 Disadvantages of ITFS

The following disadvantages of the ITFS technology are noted:

- Cost of receive sites can increase exponentially in cases where the line of sight is blocked. In northern and western Wisconsin, blockage is commonly caused by tall trees and bluffs. Extensive tower structures and active or passive repeaters can be required in order to reach *a single terrain-blocked site* (see discussion below under costs).
- The channel capacity of ITFS is limited to four channels per FCC Group, which is typically the maximum spectrum space the FCC will readily assign to one educational entity at any one geographic location. Recently, several techniques have been introduced purporting to multiplex two TV video signals on one ITFS channel. The most effective of these techniques is called *Alternate Frame Multiplexing* (AFM). Using this technique, a maximum of *two* TV channels can be placed on one ITFS frequency, accompanied by a generally tolerable loss in vertical resolution. The main disadvantage of AFM is the cost of the demultiplexers which must be placed at every receive site; these units cost approximately $5,000 each, but even so probably represent the most cost- effective multiplex technology.
- ITFS is most efficient in areas with a high density of receive sites. However, it is precisely the more rural areas of Wisconsin which require distance education service at this point in time in order to equalize educational opportunity with that available to residents of the larger communities. In fact, educational service to rural areas was the subject of a recent white paper published by the Wisconsin Department of Education. In the experience of this consultant, at least ten receive sites are required to make the installation cost efficient. Additionally, each site should be utilized at least two hours per day.
- ITFS transmissions are difficult to encrypt (or "scramble") successfully. This is due to the amplitude-modulation nature of the microwave signal and the restricted bandwidth available. Both Microband Technologies and Zenith have tried to scramble ITFS signals, with very poor results in terms of a decrease in service area and inconvenience to authorized users. Because of the wide availability of microwave converters in the consumer

aftermarket, ITFS system administrators should assume that a determined non-authorized person can routinely intercept the transmissions. This shortcoming can be a problem if copyrighted programs are used (such as some PBS series), or if some programming is delivered on a pay-per-view basis.

- ITFS channels have limited availability in many communities. Because of allocation restrictions and competition from Multiple Multipoint Distribution Service (MMDS) operators, it is unusual to obtain more than one or two frequencies in any mid-size or larger market. It is even more difficult to be able to utilize available frequencies in a non-directional manner. Often, new ITFS stations in larger markets must employ a directional antenna, thereby limiting their service to a relatively small portion of their contiguous geographic area.[1]
- ITFS is inherently a one-way video medium. Although it is theoretically possible to employ separate frequencies as an upstream video link (from the receiver to the transmit studio), the limit on available frequencies makes such a system generally impractical. Two-way paths *can* be established on intercity relays used to interconnect local ITFS networks, but reliance upon other technologies (such as private microwave) must generally be made to connect to the originating end user (i.e. the last mile). In cases where an audio return path is sufficient, the dial-up telephone system can be used effectively to establish interactivity (this is done extensively by the IHETS system in Indiana, for instance). In some systems digital circuits such as DS-0s are used upstream for interactive computer graphics and multi-media displays (this technique is presently used for audiographics education by the University of Wisconsin using voice-grade dial-up lines). Primarily for this reason, the consensus of most users and consultants is that ITFS is an interim technology that will give way to more capable and wider bandwidth systems within the next 10-12 years.
- ITFS transmit systems require towers, with all the aggravation associated with site acquisition, local building permits, and FAA clearances.
- Because of the amplitude modulation technique employed by ITFS, the cascadability of a given signal is limited. The recommended practical

Disadvantages of ITFS include: some receive sites cannot receive the line-of-sight signal, channel capacity is limited, security is difficult to implement, and the inapplicability to two-way video applications.

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[1] As mentioned previously, some MMDS operators have been scouring the country to sign up educational front institutions so they can utilize a 12 or 16 channel block as a wireless cable system. Theoretically, according to FCC Rules, the "A", "B", "C", and "G" channels must be available for educational programming 50% of the time. From a practical standpoint, however, the definition of an educational program is the subject of some interpretation. The net result is that these channels are lost to educational service in the markets where these educational figureheads are exploited.

number of times the signal may be received, amplified and retransmitted is two. Three links are possible in circumstances where cost is an overriding consideration and a somewhat noisy picture is tolerable (4 to 5 IRE of noise, typically). This means that ITFS networks which depend upon off-the-air reception will not work as successfully as do systems employing FM microwave or digital light fiber, especially if programs must be taped at the endpoints for off- line use.

- FCC and FAA applications are required to construct ITFS facilities. Because of a backlog at the FCC, it currently takes approximately one year for approval.[1] Following approval, construction takes approximately another year. Allowing one year for administrative overhead, an ITFS system typically requires three years from conception to turn-on.

3.1.8.8 Cost Considerations for ITFS Systems

The following sections give detailed cost examples for ITFS.

Numerous ITFS systems have been designed and constructed in nearly every geographic area of Wisconsin. System costs are therefore quite well known. The following tabulation represents the costs of a typical (*average*) four-channel ITFS system employing one transmit site, one studio-to-transmitter link (STL), one intercity relay (ICR), and ten receive sites:

• Engineering Design and Feasibility Study Costs	$ 5,000	
• Legal Costs	$ 1,500	
• ITFS Transmit Equipment	$225,500	
° Tower: 400' Ground or 100' Building Mount		$ 49,000
° Supporting Structure for STL		$ 5,000
° Four ITFS Transmitters at $14,000		$ 56,000
° One STL Transmitter at $14,000		$ 14,000
° One ICR Transmitter at $14,000		$ 14,000
° STL Receive system at $3,500		$ 3,500
° ICR Receive system at $3,500		$ 3,500
° One Equip Enclosure or xmit rm mods at $15,000		$ 15,000
° One Environmental Control Unit at $1,500		$ 1,500
° ITFS Remote Control Equipment .		$ 10,000
° ITFS Transmit Site Wiring & Installation		$ 7,000

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[1] As this chapter is written, there is a "freeze" on ITFS applications. It is estimated that new applications will not be accepted at the FCC for processing at least until the end of 1993.

Transmitter Combining Equipment		$ 6,000
Omnidirectional Microwave Antenna		$ 15,000
Waveguide, Coax, Hangars & Misc Hardware		$ 10,000
Performance proof & parts stock		$ 8,000
Audio return conference bridge		$ 8,000
Receive Site Equipment (10 sites)	$ 53,000	
Receive Antenna Installed		$ 2,900
Roof-mount Support Installed		$ 1,000
Converter		$ 400
Cable, Wiring & Outlets*		$ 1,000
Total Receive Site Costs (per site)		$ 5,300
*Assume existing TV monitors will be used		
Maintenance	$37,000 per year	
Technician time (shared with other systems)		$22,000 per year
Transmit & Receive site Repair Components		$15,000 per year

The equipment tabulated below refers to video studio and production hardware which is typically installed at an ITFS origination site. This equipment would be necessary regardless of the transportation technology employed, and would also presumably be available for use at the time new interconnect techniques come on-line to replace ITFS. These costs are not included in the summary totals, since they are generally considered to be the responsibility of the user.

Studio Site Equipment	$ 50,000	
Audio Return Telephone Equipment		$ 5,000
Video & Audio Production Equipment		$ 40,000
Installation of Studio Equipment		$ 5,000

3.1.8.8.1 ITFS COST SUMMARY

Professional Fees	$ 6,500
Transmit Equipment	$225,500
Receive Equipment	$ 53,000
Maintenance	$ 37,000 per year
TOTAL	$285,000 plus $37,000 per year for maintenance

The above figures represent the *per transmit location* costs of installing new ITFS systems complete with *one* single channel link to interconnect with other regional distance education systems. It is believed that these costs represent a good average figure for use in portions of the state where ITFS is not currently being employed.

Systems currently in operation can add channels at a cost of approximately $40,000 at the transmit end and $25,000 for each STL and ICR channel added to an existing system. Receive sites do not need to be upgraded *provided broad-band block converters are used.*

A caveat is in order regarding hard-to-reach receive sites. In cases where receive sites are located in valleys or behind trees, tall towers may be required. Such towers may be 200 to 500 feet high and cost $3,000 to $90,000. If receive sites are separated by great distances, active repeaters costing $100,000 to $200,000 can be required. If a receive site is blocked by a ridge or other solid obstruction, a passive repeater costing from $3,000 to $10,000 may be effective if it is designed properly.

In order to compare ITFS costs with the transportation lease costs of other technologies, the following recurring averages have been calculated. Given the average ITFS system price of approximately $285,000 and tne maintenance cost of $37,000 per year, the monthly payment would be approximately $7,000 amortized over 10 years. If 10 receive sites are employed, the per-site cost is $700 per month for four channels, compared with typical DS-3 fiber costs of approximately $1,500-$2,000 per month per site per channel.

3.1.8.8.2 Proposed New ITFS Projects and Proposed Upgrades of Existing Systems

Several ITFS projects have been identified as currently in the planning or funding stages. These projects are tabulated in Appendix B. Some of these projects represent new systems while others are upgrades of existing systems.

Of these 19 projects, only two propose to utilize some form of two-way video, although 14 plan to use upstream audio. No data carriage is anticipated at the present time. All systems are classified as regional in scope. Many of the projects propose to interconnect existing ITFS systems with other distance education systems and with new endpoints.

3.1.8.9 Evaluation of ITFS Technology

Use of new ITFS facilities as a component of the statewide distance education network is not generally recommended, unless the new facilities represent systems already planned or they increase the capacity or connectivity of existing ITFS facilities.

On the basis of the above allocation study and cost analysis, it is recommended that ITFS technology be used *only* as a peripheral last-mile link, and then only if the local distance education requirements of the subject communities will not outgrow its capabilities over the next 10 to 12 years.

ITFS should be considered for certain last-mile connections where only a few channels of one-way video are required.

When determining whether ITFS is the technology of choice for a given regional or local network, the following parameters must be observed:

- ITFS should not be considered as the primary technology if a return full-motion video path will be required at more than two or three end user locations.
- ITFS should not be used if less than ten receive sites are to be employed.
- ITFS should not be used if more than four downstream video channels will be required to all receive sites within the next ten years.
- ITFS should not be used if more than eight full-motion video channels are required on the backbone system feeding the ITFS nodes.
- ITFS should not be used for STLs or ICRs if more than two hops are involved.
- ITFS should not be used if network-quality signals are to be delivered to TV stations or for use in tape dubbing.
- ITFS should not be used if "must reach" sites are located behind ridges or trees which could not be served from the main transmitter site.
- ITFS should not be used if the system cannot be built within the next three years.

While there is no unique location in Wisconsin where ITFS should not be used because of the availability of other technology, there are locations where geological features make ITFS usage less than satisfactory (see Appendix B-7).

In numerous conversations with fiber suppliers and satellite providers, the overwhelming consensus is that it is a matter of approximately 13 years (2005) before the Wisconsin communications infrastructure will support full two-way integrated video/voice/data services on a demand basis and in a manner which is both cost effective and available at most locations throughout the state. Several external forces are converging at this same time:

- Full implementation of SONET by the LECs and the IXCs.
- Availability of seamless bandwidth in increments below DS-1 and above DS-3.
- Standardization of video compression codecs and algorithms.
- Well defined parameters for data rates and bandwidths to be used for different purposes such as Packet Networks.
- Migration of the DS-3 multiplexers to the user's site.
- Standardization of multimedia displays.
- The establishment of a ubiquitous switching structure throughout Wisconsin which operates at rates compatible with video and high speed data transportation.

Most providers agree that it will take up to 15 years for full two-way, integrated voice, video and data services to be available on a demand basis. Therefore, new ITFS systems could still be built and amortized before being replaced.

The amortization rate for ITFS equipment is generally considered to be between 10 and 15 years. Therefore, with a properly designed and conceived ITFS system the equipment could probably be *just* fully utilized by the time the transportation system would require upgrading. It should be remembered that the typical lead time to design and construct a system is two years. Adding to this time period an average of one year for administrative organization would seem to indicate that any ITFS system which can be justified on the basis of the previously described technical parameters should be either built very soon, or should probably not be built at all.

In any case, it is obvious that only the peripheral use of ITFS is appropriate, and it should not be used as any portion of a backbone system. For at least the next five to seven years, existing use of ITFS ICRs and STLs should be continued. However, as increased capacity is required, the ITFS systems should be phased out in favor of FM microwave or light fiber.

3.1.8.9.1 WECB ITFS Phase-Out Schedule

Over the course of the next few years, it would be appropriate for the WECB to turn over control and licensing of the ITFS facilities which it currently maintains. This is reasonable because ITFS has been identified as a local technology, and the WECB will be concentrating on the overlay network. The following approximate time schedule for "Turnover" of the ITFS facilities to local groups and consortiums is suggested. This schedule reflects the approximate time that licenses must be renewed, and during which the initial equipment is amortized:

Chilton ... 1997
Wausau ... 1998
Madison ... 1999

Eau Claire ... 1999
Platteville ... 1999
Green Bay ... 1999
Rhinelander ... 2000
Superior ... 2000
Lakeshore ... 2000
LaCrosse ... 2001
Central Sands ... 2001
Rice Lake ... 2001
Janesville ... 2001
Oconto Falls ... 2002
CWETN ... 2002
Green Lake ... 2002

A timetable for turnover of ECB's ITFS licenses and facilities to local groups is presented.

3.1.8.10 Network Evaluation

3.1.8.10.1 Use in State Overlay Network

Use of ITFS in the State Overlay Network is not recommended.

3.1.8.10.2 Use in Regional Networks

Further use of ITFS in multi-institution regional networks is not recommended.

3.1.8.10.3 Use in Local Networks

Use of new or expanded ITFS systems for local purposes should only be considered in very restricted circumstances, as described under 3.1.8.9 above.

3.1.8.10.4 Addressing Needs

ITFS addresses the minimum set of distance education needs, since it is not suited to extensive two-way or computer data use.

Rating in the Local Loop = 2.0

3.1.8.10.5 Advantages, Disadvantages, Benefits and Risks

For last mile applications, ITFS has serious drawbacks pertaining to interactivity and channel capacity.

Rating in the Local Loop = 1.0

3.1.8.10.6 Cost Considerations

Although ITFS is a fairly low cost technology, its *cost-effectiveness* is being steadily eroded as other bidirectional technologies become more ubiquitous as well as more reasonably priced.

Rating in the Local Loop = 3.0

3.1.8.10.7 Migration and Implementation Issues

ITFS is relatively easy to transport onto a statewide or regional network based upon light fiber or other broadband technology, but it causes a severe bottleneck when system capacity or capabilities must be expanded.

Rating in the Local Loop = 2.0

3.1.8.10.8 Ratings Total

The total evaluation numeric for the ITFS option in the local loop is 8.0, obtained by adding the above evaluations together.

3.1.9 Summary Technology Analysis: Coaxial Cable

3.1.9.1 Description

Coaxial cable consists of a relatively large inherently shielded copper or aluminum conductor along which electromagnetic waves may be propagated.

As discussed earlier, coaxial cable is primarily used by cable TV systems.

Coaxial cable represents a core technology which is the primary means of interconnect used by Wisconsin's Cable TV systems. Coaxial cable is not recommended for extensive use in the state distance education overlay network or in the regional networks, but interim employment in the local loop is expected to be cost effective for at least another twelve years. After that time, fiber transducers will be inexpensive enough to completely replace coax in the local networks. Eventually (within 20 years), even building-level Master TV systems which use signal level voltages will undoubtedly replace existing copper wiring with fiber.

Coaxial cable is deemed to have capabilities only appropriate for use in local networks.

Coaxial cable should not be confused with "twisted pair" wiring now being extensively installed within buildings to interconnect ISDN-ready telephone systems and FDDI[1] data networks. Twisted pair wiring is far less capable than coax; nevertheless four-pair Level 5 wiring (100 Mbs) is quickly becoming the wiring standard for telephone and data use at approximately $150 per outlet, displacing thin-ethernet coax. Many existing wiring infrastructures have already been installed at Level 4 (20 Mbs) or lower. Until migration to light fiber occurs at the outlet level, it will be necessary to interface twisted pair wiring with video coax at local network concentration points.[1]

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[1] FDDI stands for Fiber Digital Data Interface.

Coax is easily installed and maintained, and its use is not regulated. Coax can carry either analog or digital signals.

3.1.9.2 Reasons Coaxial Cable is Not Appropriate for the Overlay or Regional Networks

Coaxial cable, at its present stage of development, offers no significant advantages over light fiber for the carriage of signal-level voltages over wide-area networks.[2]

Coaxial cable is limited in bandwidth compared to light fiber and has significantly higher losses, disabilities which are not offset in wide-area applications by the somewhat lower transducer costs and increased ruggedness.

3.1.9.3 Network Evaluation

Although a detailed analysis of coaxial cable is not appropriate, use of such systems in the local loop may be appropriate during the migration phase. The following evaluation is therefore pertinent:

Use of coax is only recommended for local systems.

3.1.9.3.1 Use in State Overlay Network

Use of coaxial cable in the State Overlay Network is not recommended.

3.1.9.3.2 Use in Regional Networks

Use of coaxial cable in the regional networks is not recommended.

3.1.9.3.3 Use in Local Networks

Use of coaxial cable in the Local Network, whether supplied by the telephone company, cable TV companies or purchased by the institution itself can be cost effective and migration compliant.

3.1.9.3.4 Addressing Needs

In last mile applications, the low cost of coaxial cable can allow the carriage of a sufficient number of channels to make the immediate revolutionary change to light fiber unnecessary in the short and mid term. However, once the distribution network is fully digital and SONET compatible (estimated by 2005), most or all coaxial distribution links will certainly be replaced with light fiber, leaving coaxial cable to be used solely within local building wiring.

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[1] This consultant is not in favor of unshielded wiring of any type because of possible interference from electromagnetic devices. If Level 5 wiring is installed, it should be shielded.

[2] Coaxial cable has a significant advantage over light fiber in its ability to transmit high power radio frequency signals to radio and television antennas, however.

Rating in the Local Loop = 3.0

3.1.9.3.5 Advantages, Disadvantages, Benefits and Risks

Coaxial cable is much easier to splice than light fiber, an attribute which is especially useful in last mile applications where most environmental insults occur. Coaxial technology is well known, and installation service is readily available. Use of closed circuit coaxial systems is not regulated by local or state authorities, and its use has a minimum impact upon a local institution's maintenance staff.

Coaxial cable can carry both analog and digital signals, in either FDM or TDM mode. The primary use of coaxial cable today is in analog Cable TV and campus-wide "master television" applications, making local hook-up straightforward. At the present time and in the majority of cases, use of coaxial cable reduces the complexity of the interface to the local cable company.

Use of coaxial cable should be carefully monitored to ensure installation can be amortized before the local electronic transportation provider provides digital capability. In most cases, while it is possible to use digital transducers on coaxial cable, it is generally not cost effective.

Rating in the Local Loop = 2.0

3.1.9.3.6 Cost Considerations

Coax is relatively inexpensive to install and maintain. However, it does not migrate well to newer technologies.

Installation of coaxial cable costs approximately $5,000 to $6,000 per mile, exclusive of easements, pole rental and rights-of-way.

In-building wiring costs usually run approximately $250 per outlet.

Rating in the Local Loop = 5.0

3.1.9.3.7 Migration and Implementation Issues

Coaxial cable is relatively easy to maintain, and it allows the use of existing resources in many cases.

Coax does not migrate well, however. Its primary use in migration would be as a pull wire to bring in fiber cable.

Rating in the Local Loop = 2.0

3.1.9.3.8 Ratings Total

The total evaluation numeric for the coaxial cable option in the local loop is 12.0, obtained by adding the above evaluations together.

3.1.10 Detailed Technology Analysis: Educational Broadcast TV and FM and the Network Interconnection System

Broadcast television and FM radio are considered to be core technologies. Extensive educational TV and FM facilities currently operate throughout Wisconsin.

This section examines alternatives for the WECB Broadcast TV and FM Interconnect System.

WECB is the licensee of six TV and seven FM educational broadcast stations strategically located throughout Wisconsin. WECB maintains these facilities and contracts for the services required to deliver video and audio to each site.

Alternatives for upgrading the WECB interconnect network will be evaluated separately from those pertaining to the overlay network. Synergies with respect to the overlay network will also be explored in this section.

3.1.10.1 Description

3.1.10.1.1 Broadcast Outlets

Educational broadcasting uses conventional TV and part of the FM band.

Educational broadcasting uses the standard TV band receivable on all consumer television sets, the standard AM band and the lower 4 MHz of the consumer FM band tunable on all home, portable and automotive FM radios.

Two-way interaction is limited to a return telephone link.

Interactivity for broadcast stations is essentially limited to call-in programs which use the public telephone network as the return link. These occasional shows aside, broadcast technology is inherently one-way and is limited to one stereo FM and one TV channel per geographic area except in a few communities where there are additional educational facilities (for instance, Milwaukee has two educational TV stations, WMVS and WMVT, operated by the Milwaukee Area Technical College).

Television stations are assigned in the VHF and UHF portions of the radio spectrum at power levels varying from 100 kilowatts to five megawatts, using towers approximately 1,000 feet high.

FM stations are assigned by Class:

- Class A = 6 kilowatts at 328 feet above average terrain.

Wisconsin has an excellent educational TV and FM network which provides services to over 90% of Wisconsin's citizens.

- Class B or Class C2[1] = 50 kilowatts at 492 feet above average terrain.
- Class B1 or Class C3 = 25 kilowatts at 328 feet above average terrain.
- Class C = 100 kilowatts at 1,968 feet above average terrain.
- Class C1 = 100 kilowatts at 984 feet above average terrain.

Wisconsin has one of the finest educational broadcast television and educational FM radio networks in the country. These networks have provided statewide outlets for the National Public Radio (NPR), the Public Broadcasting Service (PBS) and a panapoly of locally produced programming for over 20 years. Together, the television and radio networks can reach over 90% of Wisconsin's population, whether the listeners be at home or on the road.

The maintenance and program management of these broadcast facilities have been directed by the WECB since its inception. Recently, the WECB entered into a partnership arrangement with the University of Wisconsin to jointly manage these facilities by sharing resources and personnel. Although both agencies presently retain control over the facilities licensed to them, the University concentrates its resources on programming and the WECB concentrates its resources on delivery, a trend which is consistent with the "conduit/content" dichotomy.[2]

These stations are also used for distance education purposes.

Besides providing broadcast programming directly to Wisconsin residents, there are well-established distance education systems in Wisconsin for which the broadcast stations provide a critical link to PBS and Wisconsin Public Television programming.

The state FM network also provides a Subsidiary Communications Authority (SCA) channel which carries K-12 instructional radio programming.

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[1] Whether an FM facility follows Class B or Class C denotation depends upon its geographic location. Class B stations are assigned in southeastern Wisconsin, with Class C stations located elsewhere.

[2] The WECB title of *Director of Broadcasting* and the UW title of *Director of Extension Communications* presently refer to one jointly appointed individual. The Radio and Television Divisions, as well as the Delivery Services Division, are guided from the dual director's office. It is important to note that FCC and FAA licensing should remain with the agency which has primary responsibility for programming each broadcast outlet. In general, the licenses should be as close as possible to the programmers so that one agency does not incur FCC liabilities due to the actions of another agency. In any case, the **Broadcast Interconnect System** should continue to be managed by the WECB, since it will undoubtedly form a portion of the state overlay distance education network.

3.1.10.1.2 Network Interconnect System

The Wisconsin broadcast facilities are connected to the *Technical Operations Center* in Madison via a leased microwave transportation system, supplemented by an extensive last-mile microwave STL network. WECB presently leases video and audio transportation services from MRC Telecommunications Inc. These facilities use a dedicated one-way analog terrestrial microwave network as shown in Appendix D-4.

Currently, the TV and FM signals are disributed from Madison via microwave. This costs approximately $500,000 per year in lease fees. The lease expires in late 1994.

The present MRC interconnect system extends over 300 miles throughout Wisconsin, and costs approximately $500,000 per year in lease fees, plus approximately another $30,000 for occasional use backhaul connections primarily from Milwaukee and Green Bay. This system has been serving the Wisconsin Public Radio and Television networks since 1972, connecting six television stations and nine radio stations to the WECB's operating center in Madison, Wisconsin. The present lease agreement will expire in late 1994. The system is designed to meet NPR, PBS an EI standards for network quality signals (Level 2).

A list of the video (TV) and audio (FM) outlets on this network is provided.

The video signals are presently transmitted with monaural sound (15 KHz). The video receiving locations are tabulated as follows:

- WMVS-TV, 1036 N. 8th Street, 4th Floor, Milwaukee, WI 53233
- WPNE Studio - at University of Wisconsin-Green Bay, Green Bay, WI 54300
- WPNE-TV Transmitter, Hwy. XX, DePere, WI 54115
- WHRM-TV, 3200 Park Road, Wausau, WI 54401
- WHWC-TV, Route 2, Box 245, Colfax, WI 54730
- WHLA-TV, 955 Tschumper Ridge Road, LaCrescent, MN 55947
- WLEF-TV, E1825 Hwy. 182, Park Falls, WI 54552

The audio signals also originate from the Wisconsin Public Broadcast Center (WPBC) in Madison. Four separate audio signals are distributed:

- One 15 KHz Audio Channel for Talk
- *Two* 15 KHz Audio Channels for RADIO STEREO MUSIC CHANNEL
- One 7.5 KHz Audio Channel for SCA channel

The audio receiving locations along with the delivered services are tabulated as follows:

- WPNE Studio - University of Wisconsin-Green Bay, Green Bay, WI 54300

Talk Radio
MUSIC Radio
SCA

- WPNE Transmitter, Hwy. XX, DePere, WI 54115

Talk
Music
SCA

- WHAD Transmitter - Lapman State Park, Delafield, WI 53018

Talk
SCA

- KUWS - University of Wisconsin-Superior - Superior, WI 54880

Talk
Music
SCA

- WHRM - 3200 Park Road, Wausau, WI 54401

Talk
Music
SCA

- WHWC - Route 2, Box 245, Colfax, WI 54730

Talk
Music
SCA

- WHLA - 955 Tschumper Ridge Road, LaCrescent, MN 55947

Talk
Music
SCA

- WLEF - E1825 Hwy. 182, Park Falls, WI 5552

Talk
SCA

- WLFM - 113 S. Lawe Street, Appleton, 54911 (Lawrence University)

Talk

In addition, WECB has access to two satellite uplink facilities.

There are two other important components to the WECB interconnect network:

- Ku Band uplink facility at the WPBC
- One video MRC loop to the Skokie *Teleport* uplink station which has Ku and C Band capability.

Overall, the experience with the present interconnect network has been good, and the cost has remained reasonable. On the debit side, the service is primarily one-way, impeding interaction between facilities. In addition, since the existing lease is a *service contract* rather than a *bandwidth contract*, WECB cannot take advantage of technology improvements (such as compression) to reduce its per-channel transportation costs.

3.1.10.2 Analysis of the Adequacy of the Present WECB TV and FM Interconnect Network

The following needs have been identified with respect to the TV and FM interconnect which are not being met by the existing network:

- Incremental augmentations to the video network service are relatively expensive, inconvenient, and must be scheduled in advance. Significant additions are frequently accompanied by a request to extend the term of the entire system lease. Examples of additional video capability which will be required in the near future are as follows:
  - The addition of *stereo sound* to all video routes, as recommended by PBS
  - The addition of the Separate Audio Program (SAP) channel for use in alternate language programming and descriptive audio
  - The addition of a second video loop to *Teleport* to eliminate schedule conflicts which are beginning to occur when the WECB uplink is in use
  - The addition of a backhaul video channel for routes where traffic is steadily increasing, such as Milwaukee-to-Madison and Green-Bay-to-Madison
  - The addition of a second outbound channel for use by the ITFS Narrowcast Network
  - A facility for quickly switching additional outbound or inbound capability for special event programming
  - The ability to monitor the off-the-air signal of each TV facility from Madison, and to return transmitter telemetry, as well as carry remote control commands

With the existing lease, adding services to the video and audio networks are expensive and inconvenient. The new lease must address these needs.

- Incremental augmentations to the audio network service are relatively expensive and inconvenient to schedule; examples of additional audio capability which will be required in the near future are as follows:
  - The addition of a stereo channel to the talk network
  - The ability to deliver *both* audio networks as well as the SCA channel to *every* FM station in the chain at all times, so that switching between programs can be made dynamically and remotely. This means that

ultimately four 15 KHz feeds will be required, as well as one 7.5 KHz circuit. At the present time, it is difficult to switch networks at some locations on even a long term basis. For instance, WECB may well desire to add the Music Service at WHAD at Delafield, but a significant incremental cost would be incurred.

  - The ability to obtain two-way occasional use 15 KHz stereo audio from other radio studios to the Madison control center
  - The ability to monitor off-the-air signals at each FM location, and return transmitter telemetry as well as carry remote control commands

- Because the MRC lease is service oriented rather than bandwidth oriented, WECB is not able to take advantage of the new compression and digital technologies which would allow the transmission of additional signals within the same bandwidth now occupied entirely by the analog video signal.
- Because switched capabilities do not presently exist, occasional use paths (such as backhaul circuits) must be coordinated well in advance of their scheduled times.

These needs were distilled from conversations with persons who schedule time for the TV and FM network, as well as persons in the WECB Engineering Department.

Section 3.1.11 will explore means to address these unmet needs as well as identify alternatives, along with their associated order-of-magnitude costs.

3.1.10.3 Capacity of Television Resources and Future Expansion

3.1.10.3.1 Capacity For New Broadcast Facilities

The FCC has established a "freeze" on applications for new full service TV facilities until the effect of HDTV is fully evaluated (at least until the end of 1994). Even if the freeze were not in effect, there would be scarcely any site in Wisconsin where a new TV station could be located to serve more than a handful of people. Under the FCC's allocation rules, all communities in Wisconsin with populations in excess of 15,000 persons have their full compliment of channel assignments.

Virtually all available TV channels in the state are in use. However, there is room for additional FM stations in some rural parts of the state.

Although nearly all useful educational TV spectrum is occupied, there is some allocation capability remaining for additional Class A educational FM stations in the less populated portions of the state. A statewide search conducted by this engineering firm has turned up several hundred FM channels which could be assigned in a fairly useful distribution pattern throughout Wisconsin. Most of the subject frequencies would be located in the "educational" portion of the FM band

(20 frequencies between 88.1 and 92.1 MHz), although several dozen "commercial" frequencies were also found (92.3 to 107.9 MHz). The FCC allows commercials to be broadcast only in this latter band segment, but applying for these channels usually involves a long and frequently costly process wherein a FCC hearing is held to determine the most qualified applicant.

New AM stations could only be allocated using costly directional antenna systems.

Because educational band assignments are assigned on a "first come, first served" basis, they are considered to be superior to commercial frequencies for potential use by local institutions as aural broadcasting outlets. These Class A facilities could be licensed at 100 watts or more, and could service a radius of approximately 10 miles with a stereo audio main channel and a mono audio or data SCA subchannel. Such facilities could be built for approximately $80,000 to $200,000, depending upon the costs of land and a required tower. An application to the FCC is required.

A listing of the communities for which FM channels were found has been provided to the WECB as a separate document.

Brief mention should also be made of the potential for new AM radio facilities. Although 10 to 20 high-power AM facilities could be assigned throughout the state in the existing AM band (540 KHz to 1600 KHz), these stations would require costly directional antennas for fulltime operation in order to protect cochannel frequencies at night. These costs would typically be 400% to 500% more than a comparable FM station.[1]

Aside from the existing AM band, the FCC will be making additional frequencies between 1600 KHz and 1700 KHz available for use by AM stations beginning early in 1994. Some of these frequencies have been reserved for use by existing stations which are hampered by excessive allocation restrictions, but it is expected that a window of opportunity will exist in 1994 and 1995 to construct at least 10 fairly simple and cost effective AM stations in most of the large markets in Wisconsin. In local situations where audio broadcasting technology is appropriate, the cost-effectiveness of these facilities could offset the fact that many of the older radio receivers owned by Wisconsin residents will not tune to this band.

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1. It should be noted that the University Board of Regents owns and operates daytime only AM facility WHA-AM in Madison, while the WECB is the licensee for WLBL-AM in Auburndale which also operates during the daytime hours. Research by this engineering firm has established that both of these stations could operate at night by making appropriate modifications to their antenna systems.

3.1.10.3.2 Implementation Considerations for Broadcast Facilities

A new TV station costs in excess of $2 million to build. An FM station costs about $400,000, while an AM station with a directional antenna costs over $500,000.

Construction of the transmitting plant for a new high-power TV facility typically exceeds $2.0 Million dollars exclusive of land requirements, while an FM transmit site can cost $400,000 or more. An AM facility with a directional antenna can cost over $500,000 and require over 20 acres of land. Time on the AM, FM and TV facilities is therefore extremely valuable, because of the high per-channel cost associated with construction and maintenance.

In spite of the demonstrated shortcomings of broadcasting technology for use in distance education, the addition of new Class A FM broadcast facilities may very well be appropriate for other reasons, such as to provide additional one-way outlets for local K-12 institutions, colleges or universities. In any case, it is expected that both TV and FM educational broadcasting will continue to play a role in program delivery at the regional level, perhaps by re-transmitting programming being carried on the closed circuit network. It is not recommended that broadcasting technology be used as any part of the overlay network, however.

3.1.10.3.3 Recommendations Concerning Expansion of Broadcast Facilities

Further expansion of the TV and FM network as a means of accomplishing distance education initiatives is not recommended.

Further expansion of this one-way broadcast system as a means for achieving a distance education delivery network is not recommended for several reasons. Although broadcast technology has been a reliable and faithful plow horse for many years, the inherent shortcomings of broadcast facilities dictate that its time as the primary delivery vehicle of educational programming is at an end.

- Construction and maintenance of TV, AM and FM transmitting sites is enormously expensive, and yields only one main channel per site.[1]
- Channel capacity is very limited in the populated areas of the state.

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[1] Even utilization of anticipated digital technologies would yield only two channels per site.

- The broadcast technology is essentially one-way.[1]

It is therefore concluded that the technology focus of the WECB be shifted from broadcast facilities to interactive terrestrial techniques, in spite of the fact that there is some additional channel capacity available (see discussion under section *3.1.10.3.1 Capacity*). The existing TV and FM broadcast facilities should continue to be programmed by the existing WECB/UW partnership until such time as an alternate delivery vehicle is available (such as fiber to the home or wideband cellular to the home).[2] It will be necessary that the UW/WECB combined partnership be provided sufficient resources to make effective use of the existing broadcast facilities until the alternate signal path is established. As noted previously in this document, the *TV and FM Broadcast Interconnect Network* should continue under WECB's management[3].

The existing TV and FM interconnect network currently managed by the WECB offers intriguing possibilities with respect to beginning the migration to a full statewide overlay network.

While addressing the requirements of the statewide overlay network, this section of the document examines the issues, advantages and disadvantages of pursuing various technological alternatives in order to address the future requirements identified for the WECB TV and FM Network Interconnect System. A recommendation will be made identifying an effective technology mix and its cost impact will be calculated. Finally, the issues pertinent to the design and implementation of a new interconnect system will be identified, along with preliminary recommendations concerning methods to best protect Wisconsin's investment in radio and television technology.

However, it is important that WECB continue to manage the existing network, as it could play a role in the development of the statewide overlay system.

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[1] This is true irrespective of the development of a new upstream TV service known as TV Answer. Using this new FCC authorization, a license is granted to each television market, allowing a third-party provider to carry over-the air data, audio and slow-scan video back to the various TV studios in the community on a fee basis, thereby providing a limited degree of interactivity. As a two-way technology equalizer however, *TV Answer* is both too little and too late.

[2] Note that the connection of individual residences to the state overlay network is not anticipated in the early phases of implementation. The broadcasting system, being a last-mile technology, will form an effective bridge until substantially all residents are wired for "video dial tone. The only unfortunate side effect of holding on to the TV and FM licenses this long will be a steady erosion in their value on the open market.

[3] This is an extremely important point; the overlay network attempts to *integrate* transportation technology users. To disconnect the broadcast interconnect system would promote *disintegration* at the very inception of the overlay network.

Possible synergies between uses of the interconnect system with respect to distance education delivery alternatives will also be explored.

3.1.10.4 Wisconsin Broadcast Resources

The TV and FM outlets jointly managed by the WECB and UW cover a majority of the Wisconsin state population, resulting in a very low cost per listener and viewer. Assuming the programming material is reasonably popular, this makes educational broadcasting an inherently equitable educational delivery system. At the same time, the extent and broadcast nature of the WECB network makes it also a very accessible medium.

Unfortunately, as previously mentioned, new high power TV and FM channels are not available in useful areas regardless of cost, due to spectrum limitations.

Some additional audio-rate capability can be obtained by employing the "SCA channel" for the FM stations in areas where they are unused, and the "Second Audio Program Channel" for the TV stations.[1] Certain portions of the TV signal can also be used for digitally based services (such as closed captioning, FAX and slow-scan). These specialized techniques require dedicated equipment which must be provided to each receive location, partially negating the advantage of the broadcast technology. The required decoding equipment ranges in cost from $1,200 for an installed SCA receiver to $5,000 for TV digital service extractors.

The Wisconsin Educational TV and FM network is discussed in more detail in the *Network Analysis* section below.

It is expected that the use of broadcast technology will continue and expand in the forseeable future.

3.1.10.5 Future Role of Broadcast Facilities in Distance Education

It is expected that the use of broadcast technology will continue and even expand well into the 21st Century, serving low-density fixed receivers as well as mobile radios and television sets. The licensees of these facilities are expected to be local educational entities, with the network interconnect system being managed by the state.

The following alternatives are available for the TV and FM Broadcast Network.

3.1.11 Network Analysis - Identification of Technology Alternatives for the Broadcast Network

Several alternatives are available to design an improved and expanded TV and FM Network Interconnect System. These alternatives must be explored quite apart from the requirement to establish a statewide distance education overlay network, since the WECB is obligated to continue to provide interconnect support to the broadcast facilities which make up the Wisconsin Public Broadcasting Service. While the interconnect network is evaluated, however, the requirement that it be maximally compatible with the future overlay distance education network should be kept firmly in mind.

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[1] The SAP channel can be used to provide a foreign language soundtrack or as a second audio programming outlet. The WECB TV sites are equipped to use the SAP channel, but the TOC would need to be updated.

Identified in the tabulation below are those technologies which are considered appropriate for consideration with respect to replacing or augmenting the present MRC Interconnect. The logical prospects for future development will be explored for each viable alternative, along with the regulatory caveats and relative costs.

3.1.11.1 No Initiative

The following discussion presents an analysis of the "business as usual" option, in order to establish a baseline from which the other alternatives can be evaluated.

3.1.11.1.1 Discussion

The Interconnect System lease with MRC could certainly be renewed under presently existing terms and for any arbitrary period of time; this fact was confirmed by MRC personnel during interviews. Since all MRC equipment used in the system is amortized, this option has the obvious advantage of low cost, although some flexibility in utilizing bandwidth would be lost compared to the other options described below. In addition, recent events have caused a significant reduction in the cost of wideband common carrier services, which is enhancing the competitiveness of the "bandwidth on demand" concept.

The existing lease could simply be renewed. This would yield low cost, but would not provide interconnection with any distance education networks and may result in duplication of resources.

However, **not** implementing expanded capability of some description would mean that the Interconnect network would be *disconnected* from the state, regional and local initiatives which could potentially serve as sources and destinations for Interconnect programming. At some point in the future, the Interconnect would be unable to share in the economies of scale which would be realizable in a coordinated and planned statewide environment. Such a "business as usual" alternative would undoubtedly result in some overbuilding and duplication of effort. For the most part, local radio and television stations would not have the ability to easily utilize other state resources such as those represented by the technical colleges (e.g. MATC in Milwaukee originates a great deal of programming). WECB would also have no permanent equipment to show for its lease term expenditures.

On the other hand, if future-oriented technologies are phased into the Interconnect system, compatibility of terminal and interface equipment will ensure maximum connectability with other statewide and regional systems. Resource usage will therefore be maximized, assuming that future technologies proceed reasonably as planned, as would be the case with a state-level directed distance education program.

Implementation of High Definition TV (HDTV) could have an effect on the current system.

One wildcard in the "business as usual" scenario is the advent of High Definition Television (HDTV) which has been placed on a "fast track" at the FCC.[1] It is the opinion of this consultant that once an FCC standard is adopted, HDTV will be quickly implemented by the commercial TV stations. Viewer demands will then force compliance upon the public TV sector within five years. HDTV is a digital technology and will require MRC to make a substantial investment in their microwave system if it is to be carried; this consideration alone classifies the "business as usual" scenario as a very risky strategy.

There is one other consideration which may seem spurious at the present time, but which must be faced nonetheless. There is a very real possibility that high-power over-the-air television may be obsolete within approximately 25 years except as a fill-in technology employed in geographic areas which are not practical or economical for connection by light fiber. If such a scenario comes to pass, and many broadcast experts believe it will, it would be well for WECB's Interconnect to be "plugged in" to the developing fiber infrastructure.

3.1.11.1.2 Evaluation of "Business As Usual" Alternative

In the evaluation that follows, the "Business As Usual" alternative with respect to the broadcast interconnect network is rated by assigning a numeric value to each of the component categories.

Categories for the interconnect system include the following:

- Effectiveness in Addressing Needs.
- Advantages, Disadvantages, Benefits and Risks.
- Order of Magnitude Cost Considerations.
- Migration and Implementation Issues.

For a full discussion of the evaluation factors, see Section 3.1.1. The figures presented in the evaluation of costs are described in detail in the electronic spreadsheet model provided under separate cover (an example is included herein as Appendix P).

Effectiveness with Respect to Addressing Needs

- Addresses only the need to keep costs low; all other needs are unmet.

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[1] Making the early implementation of HDTV even more likely, the four major consortiums representing competing non- compatible HDTV technologies have recently agreed to pool their resources and to support *one* overall standard for the U.S.

Rating = 1.00

Advantages, Disadvantages, Benefits and Risks

This alternative is low cost but will not meet any of the other needs.

The following discussion summarizes the advantages and disadvantages of the "Business as Usual" scenario:

Advantages & Benefits

- No organizational impact or migration disruption.
- Competitive technologies will become less expensive and more readily available as time goes on.

Disadvantages

- Possible under-utilization of other state resources.
- Inability to explore synergies with the DOT and Distance Education IT initiatives.
- Continued inflexibility of delivery system.
- No equity build-up.
- Disappointing cost savings from renewal of lease.

Risks

- High probability of inadequate capacity and scheduling difficulty within two years.
- Delay in implementing a modern communications system may result in lost opportunities to share programming and secure infrastructure partners.

Rating = 1.0

Order of Magnitude Cost

The following summary tabulates representative costs obtained from the existing transportation vendor for the "Business as Usual" scenario. Although the raw costs are relatively low, *cost- effectiveness* is minimal because of a lack of flexibility and the difficulty to incorporate future technology improvements (See Appendix D-4):

- For the Video Network.
  - 3 year term = $23,395 per month ($280,740 per year) + $23,395
  - 5 year term = $21,640 per month ($259,680 per year) + $21,640
  - 7 year term = $21,055 per month ($252,660 per year) + $21,055

- For the Audio Network.
    - 3 year term = $13,227 per month ($158,724 per year) + $13,227
    - 5 year term = $12,235 per month ($146,820 per year) + $12,235
    - 7 year term = $11,904 per month ($142,848 per year) + $11,904
- Nominal Totals.
    - 3 year term = $36,622 per month ($439,464 per year) + $36,622
    - 5 year term = $33,875 per month ($406,500 per year) + $33,875
    - 7 year term = $32,959 per month ($395,508 per year) + $32,959

Rating = 2.0

Migration and Implementation Issues

- No WECB migration difficulties are expected with respect to existing capabilities; the availability of this option is immediate.
- Future compatibility with respect to other agencies and initiatives will probably be significantly impaired.

Rating = 1.00

The total evaluation metric for this option is **5.00**, obtained by adding the above evaluations together.

3.1.11.2 Additional Channels for the Existing MRC System

Another alternative is to keep the current carrier but add the new services which are desired.

The following discussion presents an analysis of the option of continuing to utilize the current carrier for the Interconnect system while increasing the available channel capacity.

3.1.11.2.1 Discussion

MRC has made several options available for increasing the channel capacity on the existing microwave system with respect to both the TV and the FM networks. These options include:

- Adding stereo sound to the TV video.
- Adding SAP to the TV video.
- Adding Music Network to WHAD.
- Providing per hour simplex video channel service.

These options add a considerable amount of flexibility to the video and audio transportation system, but they still represent service oriented scenarios and do not allow multiplexing by WECB. MRC has not established an occasional use audio tariff.

3.1.11.2.2 Evaluation of Additional Channel Alternative

Effectiveness with Respect to Addressing Needs

- Addresses need to add capacity, but does not allow WECB to employ video compression to increase capacity without additional cost.
- Will not conform to State Overlay Network in all respects.
- WECB still without nodal switching control.

This option will meet more of the identified needs, but still will not allow WECB to take advantage of new technologies such as compression.

Rating = 2.00

Advantages, Disadvantages, Benefits and Risks

The following discussion explores the advantages and disadvantages of the "enhanced MRC" option.

Advantages

- Minimal organizational impact and migration disruption.
- Competitive technologies will become less expensive and more readily available as time goes on.
- Provides two additional audio channels for the TV stations at about the same network cost presently being paid.

Disadvantages

- Disappointing cost savings for lease renewal.
- Inability to explore synergies with the DOT and Distance Education IT initiatives.
- Continued inflexibility of delivery system.
- No equity build-up.

This option will continue the inflexibility of the old lease and will not provide synergies with other initiatives.

Risks

- High probability that network will require reconfiguration during the term of the lease to provide more TV and FM channels to some endpoints and less to others.

- Delay in implementing a modern communications system may result in lost opportunities to share programming and secure infrastructure partners.

Rating = 2.00

Detailed costs for this option are provided.

Order of Magnitude Cost

The costs tabulated below were obtained from MRC in response to a *Request for Information*. The ratings for these costs are adjusted to reflect the capabilities and the flexibility of the service to be provided:

- Add Stereo Channel to the Video Network.
  - 3 year term = $26,650 per month ($319,800 per year) + $26,650
  - 5 year term = $24,651 per month ($295,812 per year) + $24,651
  - 7 year term = $23,985 per month ($287,820 per year) + $23,985
- Add Stereo Channel and SAP Channel to the Video Network.
  - 3 year term = $29,905 per month ($358,860 per year) + $29,905
  - 5 year term = $27,662 per month ($331,944 per year) + $27,662
  - 7 year term = $26,915 per month ($322,980 per year) + $26,915
- Occasional Use Simplex Video *to* the Affiliates.
  - To Milwaukee = $204 per hour
  - To Green Bay = $252 per hour
  - To Wausau = $262 per hour
  - To Wheeler = $290 per hour
  - To Park Falls = $334 per hour
  - To La Crescent = $240 per hour
- Occasional Use Simplex Video *from* the Affiliates.
  - From Milwaukee = $204 per hour
  - From Green Bay = $252 per hour
  - From Wausau = $262 per hour
  - From Wheeler = $290 per hour
  - From Park Falls = $334 per hour
  - From La Crescent = $240 per hour
- Nominal Totals for network with 3 audio channel video.
  - 3 year term = $43,132 per month ($517,584 per year) + $43,132
  - 5 year term = $39,897 per month ($478,764 per year) + $39,897

- 7 year term = $38,819 per month ($465,828 per year) + $38,819

Rating = 2.00

Migration and Implementation Issues

The following issues have been identified with respect to migrating the interconnect network to the proposed new configuration:

- Minimal WECB migration difficulties are expected; service is available within 6 months ARO.
- Future compatibility with respect to other state agencies and initiatives will probably be significantly impaired.

Rating = 2.00

The total evaluation metric for this option is **8.00**, obtained by adding the above evaluations together.

3.1.11.3 State-Owned Transportation System

The following discussion examines the alternative of replacing the existing MRC microwave infrastructure with a state-owned system. A preliminary evaluation has determined that because of the enormous capital costs involved in designing and constructing a new private light fiber network or a statewide microwave system, the only viable option for a state-owned network would be to employ the existing DOT/DSP microwave system. This network is diagrammed in Appendix E-1.

The next alternative is to replace the existing network with a state-owned system which would use the existing Dept of Transportation facilities.

It has also been determined that there would be no practical benefit to separating the FM and TV networks so as to employ different transportation media. The remainder of the alternatives presented will assume that both modes will be transmitted as an integrated signal.

3.1.11.3.1 Summary Description of State Radio Resources

At the present time there are five Wisconsin public safety radio systems which can be considered statewide in scope:

There are currently five statewide public safety radio systems in Wisconsin.

- DOT Division of State Patrol, Bureau of Communications Systems (DOT/DSP).
- DNR Communications Section Repeater Network.
- DOT Division of Highways System.
- DMA Division of Emergency Government System.
- DHSS Emergency Medical System.

Using the DOT system for network delivery is technically possible.

This alternative would also allow future connection with regional distance education networks.

The DSP system is by far the most sophisticated radio system among those listed and employs a single-channel-per-site repeater network called the SCN (Statewide Communications Network). These sites are interconnected by the State Microwave Network (SMN) to the central DSP dispatch point. Approximately 59 tower site locations are used (see Appendix E-1).

The DNR communications system is the largest radio structure in terms of tower locations, employing 94 sites as shown in Appendix F-5. The DNR utilizes many sites which would make logical extensions of the DOT microwave system if one statewide network were to be utilized for public safety, distance education, and the network interconnect.

The Division of Highways, Division of Emergency Government and the EMS system use many of the same towers employed by DOT/DSP, as shown in Appendix F. Some additional sites are utilized by each division to fill in and extend the radio resources in order to meet each agency's unique requirements. Altogether there are approximately 211 state-owned tower sites including those already utilized by WECB for the TV and FM facilities.

The present Wisconsin radio environment can be characterized as a *non-integrated system* whereby frequencies, planning and system infrastructure resources are not fully shared. This contrasts with central management systems employed by such states as Florida, which manages a shared architecture, utilizing in-place tower and microwave resources to benefit all agencies.

3.1.11.3.2 Discussion of DOT Microwave Alternative

Using the DOT/DSP microwave backbone as a network delivery is certainly possible from a technical standpoint, if organizational and administrative roadblocks can be overcome. As a state-owned system, it would make maximum use of the state's investment in communications technology, and could carry some or most of the TV/FM traffic on those routes where use of fiber is presently not cost-effective, thereby providing a logical migration path. It would also allow WECB to build equity in interface and multiplexing equipment while assisting another state agency to pursue its communications objectives.[1]

Last mile links could be accomplished using microwave STL, light fiber or other secure means. Because of the extensive nodal control possible with the DOT/DSP microwave system, WECB could be "plugged in" to nearly any regional distance education or local production facility within range of the backbone.

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[1] The recently completed *Wisconsin Statewide Mobile Radio Study* concluded that the DSP interconnect should be upgraded to digital technology.

There is an especially fortunate synergy between the microwave frequencies utilized by DOT/DSP and the frequency bands which the FCC permits to be assigned for transportation of television broadcast signals. The TV Auxiliary Broadcast Service is assigned the following frequencies:

- Channels A1 through A10: 17 MHz channels beginning at 1991 MHz.
- Channels B1 through B10: 25 MHz channels beginning at 6875 MHz.

These frequencies are *immediately above* the frequencies employed in the DOT/DSP microwave backbone, which are in the 1875 MHz to 1975 MHz and 6550 MHz to 6800 MHz ranges. The significance of this serendipitous arrangement is that WECB could employ the *same microwave antennas and waveguide* utilized by DOT/DSP, thereby not placing an additional burden on the tower for the backbone interconnect. Potentially, this would save a great deal of money in system construction.

It is important to note, however, that the DOT/DSP microwave backbone system is built with segregated funds collected from gasoline taxes. Preliminary talks with DOT staff indicated that conceptually the sharing of facilities may be possible, but the workability of the arrangement with respect to administrative authority, maintenance, and proper compensation would require a good deal of thought and negotiation.

There are significant administrative issues which would need to be resolved for this option to be accomplished.

It should also be noted that microwave frequencies are limited and there is a substantial degree of contention for them by other users. It is considered unlikely that more than four full-motion channels could be added to the microwave backbone, although compression techniques could increase this number to eight.

3.1.11.3.3 Evaluation of DOT/DSP Alternative

Effectiveness with Respect to Addressing Needs

- Potentially addresses all needs of the interconnect network except the need for unlimited bandwidth.
- Capacity of system may restrain the full integration of the interconnect system with the state distance education overlay system unless some light fiber parallel routes are employed.

Rating = 3.00

Advantages, Disadvantages, Benefits and Risks

The following advantages and disadvantages have been identified for this interconnect option:

This option potentially meets all needs and makes maximum use of state facilities.

Advantages

- Maximum utilization of existing state resources.
- Maximally flexible in terms of nodal switching, access to bandwidth, and interconnection with other regional facilities.
- Subject to capacity limitations, the DOT system could also be used as part of the State Distance Education overlay network.
- The system could be utilized for the compressed video needs of DOT and other state agencies.
- Equity would build up in interface equipment (the most likely scenario is that WECB would own its microwave radios and multiplexers, while DOT would maintain ownership of towers, antennas, and waveguides).
- Route diversity and emergency power are already built into the system.

Disadvantages

- Largely bypasses commercial carriers, although they would still be used for some functions such as the MRC link to *Teleport*.
- Will not expand without limit due to frequency limitations; would have to be augmented with other technologies relatively early in the implementation plan.
- FCC applications are required, leading to some uncertainty with respect to obtaining the required new frequency assignments.
- Strengthening of some towers will undoubtedly be required to hold STL dishes, leading to additional costs.

Risks

- Uncertainties associated with DOT/DSP as a business partner, including future lease negotiations.
- Uncertainties during outages concerning the proper maintenance team to deploy (for instance, it may not be immediately obvious whether a fault is due to a radio failure or an antenna failure).

Rating for this Alternative = 3.00

Order of Magnitude Cost

- To Upgrade the DOT/DSP Microwave Backbone.
- To Install STL links for the last mile.
- Nominal Totals.

- $2,300,000 for equipment, installation and engineering
- $810,000 for site acquisition

Rating = 4.00

Migration and Implementation Issues

- Moderate but tolerable disruption associated with installing new microwave system and re-aiming STLs.
- Opportunity to begin construction of the distance education network using continuing budget funds would allow a start as early as 1994.
- Future compatibility with respect to other agencies and initiatives are inherent, with the realization that future migration would include many non-microwave routes in order to incorporate the rapidly expanding needs of the distance education network.
- The system could be available within 18 months, assuming favorable negotiations with the DOT and DSP.

Rating = 3.00

The total evaluation metric for this option is **13.00,** obtained by adding the above evaluations together.

3.1.11.4 Utilizing *Regulated* Carriers

The following discussion presents an analysis of the option of utilizing common carriers regulated by the state and federal governments as IXCs and LECs.

3.1.11.4.1 Discussion

The regulated carriers primarily use light fiber and microwave to deliver DS-3 and DS-1 circuits between Points-of-Presence (POPs) and from the POPs to their corporate and government clients. Although a substantial infrastructure is in place throughout Wisconsin (see the attached example MCI fiber map of Appendix D-7 for instance), a great deal of relatively expensive interface equipment is required in order to activate a loop for a new user. The costs associated with this equipment are difficult to estimate for any given project, and depend to a large extent upon the availability of other customers in order to reduce the incremental costs. Because of these uncertainties, several vendors (such as *Sprint* and *Access Wisconsin*) have declined to supply estimated costs in response to a Request for Information (RFI) which was sent by this office to all relevant common carriers.

The next alternative is to use LECs and IXCs to carry the network signal.

This alternative would be quite expensive, as sophisticated switching equipment would be required.

It should be mentioned that the regulated carriers interviewed by this consultant are very interested in supplying the State of Wisconsin with discounted video and audio

PSC regulations would prevent the discounting of this service by the providers.

transportation. Up to this year, they have been constrained by tariff regulations, primarily by the Wisconsin PSC, to price capacity requiring new construction in a *fully compensatory manner.* Carriers are still not allowed to consider the tax impact of their pricing, or whether additional government and corporate customers would utilize the new capacity once it is built and therefore should be assessed a share of the construction costs. Some other states, notably Tennessee, have addressed this problem through legislative action.

3.1.11.4.2 Evaluation of Regulated Carrier Alternative

Effectiveness with Respect to Addressing Needs

- Addresses all needs with the exception of the need to minimize costs.

Rating = 5.00

Advantages, Disadvantages, Benefits and Risks

The following advantages and disadvantages have been identified with respect to the regulated carrier interconnect option:

Advantages

- Maximum flexibility because codec is on user side of demarc (assuming recommended lease standards are in force).
- Occasional use is relatively easy to obtain upon demand.
- Inherently a two-way system to all endpoints.
- Open-ended capacity...additional channels available as needed.
- Good compatibility with other regional distance education networks.

This option would result in a flexible, compatible network at extremely high cost.

Disadvantages

- Some new construction lease costs are extremely high.
- Costs will undoubtedly decline in the future (as recommended in the lease standards, leases should contain a technology re-opener, although this usually does not eliminate the obligation of the user to repay the vendor for his equipment investment).
- Fairly high cost of adding other users to system, depending upon their geographic location (compared to microwave technology).

Risks

- High probability that early construction will result in a substantial cost penalty because of decreasing prices, especially if the PSC rules in favor of lower rates for educational entities.
- It is likely that the network would require a complex management structure in order to achieve the cost benefits of a multi-vendor solution; this would have a substantial staff impact upon WECB and other associated agencies.

Rating = 4.00

Order of Magnitude Cost

Detailed cost information is given.

These costs were obtained in the fourth quarter of 1993. It is expected that these costs will gradually decrease throughout the next few years.

- DS-3 two-way Video Network Access (representative pricing from MCI for a three year term):

  Madison: \$6,125 per month + \$1,590 to install
  Milwaukee: \$5,110 per month + \$1,590 to install
  Green Bay: \$6,455 per month + \$1,590 to install
  DePere: \$6,455 per month + \$1,590 to install
  Wausau: \$7,010 per month + \$6,505 to install
  Colfax: \$5,110 per month + \$1,590 to install
  LaCrescent: \$5,185 per month + \$1,254 to install
  Park Falls: \$21,140 per month + \$1,590 to install

- DS-3 two-way Video Network Inter-Office Charges (representative pricing from MCI for a three year term):

  Milwaukee: \$17,613 per month
  Green Bay: \$22,765 per month
  DePere: \$22,765 per month
  Wausau: \$23,665 per month
  Colfax: \$26,185 per month
  LaCrescent: \$21,685 per month
  Park Falls: \$30,223 per month

- DS-1 two-way Audio Network Access (representative pricing from MCI): **Note:** It is not considered to be cost effective to lease capacity in less than DS-1 increments.

  Madison: \$781 per month + \$1,338 to install
  Milwaukee: \$553 per month + \$1,338 to install
  Green Bay: \$719 per month + \$1,338 to install

DePere: $719 per month + $1,338 to install
Wausau: $670 per month + $778 to install
Colfax: $553 per month + $1,338 to install
LaCrescent: $1,527 per month + $1,790 to install
Park Falls: $3,183 per month + $1,338 to install

- DS-1 two-way Video Network Inter-Office Charges (representative pricing from MCI):

Milwaukee: $2,520.68 per month
Green Bay: $2,801.40 per month
DePere: $2,801.40 per month
Wausau: $2,855.40 per month
Colfax: $3,006.60 per month
LaCrescent: $2,736.60 per month
Park Falls: $3,249.60 per month

- Usage sensitive inter-office charges (this is a switch service which would supply *additional* capacity on an occasional basis):
  - Usage averages $3.00 for the first 30 seconds
  - Subsequent 6 second increments average $0.25 depending upon the time of day
- Nominal totals for network:
  - 3 year term = $256,168 per month ($3,074,016 per year) + $27,894

Rating = 2.00

Migration and Implementation Issues

- Moderate but tolerable WECB migration disruption expected, provided that installation begins at least one year before the MRC contract expires.
- Future compatibility with respect to other agencies and initiatives is expected to be good but may require relatively expensive interface equipment.
- The availability of the required service is expected to be one year ARO.

Rating = 4.00

The total evaluation metric for this option is **15.00,** obtained by adding the above evaluations together.

The next alternative is to move the TV and FM network to satellite resources obtained from PBS.

3.1.11.5 Leasing Satellite Transponder Capacity

The following discussion presents an analysis of the option of utilizing satellite as the combined transportation and last mile links. Although there are several providers of this capability, only PBS responded with interest to the RFI. Suppliers such as Hughes may be interested in the future when they have established an administrative network which will address the needs of the smaller in-state user.

3.1.11.5.1 Discussion

This method is successfully used in other states.

Several states, notably Louisiana and Alaska, are contemplating the use of the PBS satellite for in-state video distribution. This is especially effective for the broadcast (outbound) link, because a relatively inexpensive receive terminal can be installed nearly anywhere at any time to expand the network. However, upstream (inbound) video capability is not so easily accessed. Returning video to the main distribution point either must be done by other means, or must be scheduled through an occasional use transponder (usually Single Channel per Carrier, or SCPC). The latter option requires a fairly expensive uplink at the originating site. Coordination of occasional use transponder time is generally a substantial effort, and frequently requires the ability to change satellites at the last moment when scheduling conflicts arise. These requirements put a substantial burden on the end user.

3.1.11.5.2 Evaluation of Leased Satellite Alternative

Effectiveness with Respect to Addressing Needs

- Addresses all downstream (outbound) needs with the exception of the need to minimize costs; significant problems exist with respect to interactivity.
- Upstream links would be difficult to coordinate and will place a cost and expertise burden upon the end user.

Rating = 2.00

Advantages, Disadvantages, Benefits and Risks

The following advantages and disadvantages have been identified with respect to the satellite interconnect option:

This alternative is expandable and flexible, but does not allow for return paths.

Advantages

- Infinitely expandable as a broadcast delivery system to as many endpoints as desired.
- Codec is on WECB's side of the Demarc, allowing multiplexing of required TV and FM broadcast signals.
- Occasional use is obtainable, but must be scheduled.
- Allows an inherent full-time link to national markets for Wisconsin-based programming.

Disadvantages

- Return paths either must use other technology, or are difficult to coordinate and relatively expensive to implement.
- Fairly high cost of adding other upstream users to system, depending upon their geographic location.
- Additional transponder channel capacity depends upon future availability.

Risks

- Subject to disruption due to satellite transponder failures.
- Fractional transponder usage requires edge-of-the-art compressed video, which unavoidably compromises picture quality to some extent.
- Since the Wisconsin application proposes to rebroadcast the received signal at the local TV stations, a careful analysis would have to be conducted with respect to transponder usage fraction versus acceptable quality.

Rating = 3.00

Order of Magnitude Cost

The following cost estimates were obtained from PBS with respect to the Telstar 401 satellite:

- Lease of FULL transponder = $1,400,000 per year.
    - This cost could be shared with other educational users, such as those from Louisiana and Alaska, by employing compressed video
- Cost of satellite downlink earth terminal = $5,500 per receive location.
- Cost of steerable non-motorized or portable low-power digital uplink = $140,000 - $200,000 (SCPC carriers cannot be used on the digital transponders, but might be usable on an occasional basis on C-band).
- Average cost to reach nearest POP to carry upstream video to an uplink = $150,000 plus $100 per hour usage charge.

Rating = 2.00

Migration and Implementation Issues

- A fairly high degree of WECB migration disruption is to be expected.
- Future compatibility with respect to other agencies and initiatives is not expected to be good, especially with reference to the upstream path.

- Availability of transponder time is subject to some uncertainty, since PBS has not yet committed to purchasing an additional transponder from AT&T.

Rating = 2.00

The total evaluation metric for the satellite option is **9.00**, obtained by adding the above evaluations together.

3.1.11.6 Summary Analysis: *VSAT* Satellite

The following discussion relates to a technology deemed to be non-viable for exclusive use in a broadcast network interconnect system at the present time, but which should be monitored for future applicability. This technology has not been rated because of the fatal flaws discussed below.

Use of VSAT satellite for the TV and FM network is not viable at this time, but may be in the future.

3.1.11.6.1 Discussion

VSAT (Very Small Aperture Terminal) services use satellites in geosynchronous orbit to communicate between earth stations using relatively low cost uplink/downlink combination dishes. Data rates are currently supported up to 56 Kbs, which would enable voice usage. The main use for VSATs would be to interconnect tower sites for the audio network. VSATs would be considerably more expensive than leasing terrestrial capability unless a large number of them could be employed in a many-to-many environment.

VSATs cost approximately $15,000 to install and $130 per month each to use as a DS-0 connection.

3.1.11.7 *The Hybrid Interconnonect System* - The Recommended Alternative

3.1.11.7.1 Discussion

As a result of the evaluation of alternatives presented in the previous sections, it is clear that no single method of forming the broadcast interconnect is currently appropriate. Therefore, a *hybrid* system is recommended to be installed over the period of time from 1993 to 2000, in order to effectively meet the demonstrated needs, and in order to be as compatible as possible with the distance education overlay network.

A "mixed technology" solution could make maximum use of existing facilities and allow cost savings through the use of multiple vendors.

Effectiveness with Respect to Addressing Needs

The mixed technology multi-vendor scenario has the potential of meeting all identified interconnect needs.

Rating = 5.00

Advantages, Disadvantages, Benefits and Risks

The primary advantage of the hybrid option would be the ability to select the highest rated alternative for each network link, thereby minimizing the disadvantages and maximizing cost-effectiveness:

- Primary routes which follow both the interconnect paths and the distance education overlay paths could be based upon the MRC routes, thereby achieving the benefits of an unregulated carrier.
- Primary routes which follow both the DSP microwave paths and the distance education overlay paths could be based upon the DOT routes, thereby providing an alternative to MRC.
- Primary routes which follow both the interconnect paths and existing IXC fiber can be used wherever they are cost-effective, and where high capacity is required.
- Secondary routes could utilize a mixture of existing STLs (re-aimed), MRC, and local telephone companies.
- The most efficient selection of vendors could be accomplished by sending an RFP to all potential interconnect transportation vendors no later than the third quarter of 1993. All vendors should be encouraged to make the interconnect system as compatible as possible with the distance education overlay network.
- The only appreciable disadvantage of the hybrid system is that there will be some additional administrative load on the network manager due to servicing a multi-vendor network. As a minor factor, there will be extensive engineering time and expertise required to prepare the RFP and evaluate the responses.

Rating = 5.00

3.1.11.7.2 Costs

The increased administrative costs due to a multi-technology multi-vendor solution are expected to be subsumed by the savings received from direct competitive bidding.

Rating = 4.00

3.1.11.7.3 Migration and Implementation Issues

In order to establish an effective migration plan which is flexible enough to employ the multi-vendor solution will require a single-minded approach to state funding and staffing. A long-term goal must be established and adhered to, through good times and bad.

Fortunately, use of continuing budget dollars to fund the interconnect network may well trample the path for the distance education highway to follow.

Rating = 4.00

The total evaluation metric for this option is **18.00**, obtained by adding the above evaluations together.

3.1.11.7.4 Evaluation Summary

The following table summarizes the metric evaluation of the viable alternatives, in order by increasing desirability:

• **"Business As Usual" Alternative:**	5.00
• **Additional Channel Alternative:**	8.00
• **Satellite Alternative:**	9.00
• **DOT Microwave Alternative:**	13.00
• **Regulated Carrier Alternative:**	15.00
• **"Mixed Technology" Hybrid Alternative:**	18.00

In the analysis, the DOT Microwave alternative rated the best.

3.1.11.7.5 Discussion of Recommended Technology Mix

The following components represent the ideal evolution of the WECB interconnect system (subject to the results of the RFP to be let in September, 1993):

- Use MRC for certain low-volume links where service transportation is acceptable, such as:
  - Madison to Teleport
  - Teleport to Madison
- Use the DOT/DSP microwave system for portions of the network backbone, except at sites where tower capability or frequency allocations are not favorable.

It is recommended that ECB use a technology mix involving the existing lease provider, the DOT network, and LECs and IXCs to obtain the best price/performance ratio.

- Use fiber carriers to provide links where microwave is not feasible, and where high capacity is required.
- Use LECs where the costs compare favorably with the use of microwave STLs.
- To the extent possible, make the TV/FM interconnect conform to the State Overlay Network design.

This system is deemed to be the most cost effective of the alternatives offered for the term up to the planning horizon.

3.1.11.8 Migration and Implementation of the New System

3.1.11.8.1 General Discussion

It will take an estimated two years to construct the backbone required for the network.

The DOT/DSP network represents a substantial investment in radio technology as well as a fundamentally sound resource. In the opinion of this consultant, it is worth a considerable amount of time and effort in order to utilize it.

The DOT/DSP network has route redundancy, and has an already supported endpoint near to *every WECB required location*.

Budget phasing should be structured to correspond to a realistic construction schedule, which is estimated at two years for the backbone. Use of MRC for a year or two may be appropriate for some routes such as Madison to Park Falls which are at the end of a cascade.

The recommended technologies would result in a system which is as flexible as possible and which utilizes an open architecture consistent with required system performance.

3.1.11.8.2 Requirement For Bandwidth Oriented Pricing

This recommendation will provide adequate capacity and a good growth path. It will also provide DOT with some improvements in its systems.

The recommended technology mix will ultimately make available sufficient network bandwidth to accomplish the TV and radio interconnect system as described herein, both for dedicated service and for demand service. Since bandwidth is being utilized, there would be no additional cost to WECB if additional signals are multiplexed or mixed within the allocated bandpass. For instance, if compressed video is used, the additional bandwidth surplus could be used for other WECB signal transmission purposes such as nodal control.

3.1.11.8.3 Agency Cooperation

Hopefully with the exercise of cooperative planning throughout the Wisconsin state agencies, the above tabulated suggestions and procedures will enable the needed creative forces to be applied in order to solve the demonstrated problems faced by all. For instance, the DSP requires an update of their analog backbone to digital technology, as well as a compressed-video distance education link to Fort McCoy; both of these requirements fit well with the program outlined herein.

3.1.12 Summary Technology Analysis: Low Power FM Stations

The next alternative technology for the distance education network is low power FM.

3.1.12.1 Description

Low power FM facilities are the FM analog to LPTV facilities. LPFM stations generally utilize lower power and antenna heights than full-power facilities, and have a service range restricted to approximately seven miles.

Low power FM stations, usually referred to as "Translators", are reasonably available, but offer no advantage over Class A FM facilities in the educational band.

LPFM facilities are not suitable for primary use in the Wisconsin distance education network for the same reasons that full-service facilities have been excluded. Use by local institutions may well be effective, however.

3.1.12.2 Implementation Considerations

Low power 10 watt FM translators can be placed in most locations throughout Wisconsin with the exception of the Milwaukee, Madison, Appleton and Green Bay metro areas. These facilities typically are employed to boost the strength of an FM facility which may be too far away to be received by the public directly. Alternatively, the audio signal may be delivered by satellite, microwave or landline. A stereo audio main channel, as well as either a mono audio subchannel or data subchannel, can be provided.

This technology is useful only to deliver one or two audio channels to a small area.

An application to the FCC is required in order to implement a low power FM translator, and these facilities usually cost approximately $40,000 to $100,000 to build, depending mostly upon costs associated with the antenna supporting structure.

Low power FM can be an efficient means of delivering one or two audio channels to a small area which would be otherwise difficult to reach by conventional FM.

3.1.13 Summary Technology Analysis: VCR Tapes and Floppy Disks (Magnetic Media)

Magnetic media are one-way technologies which clearly are not suited to be primary technologies in the proposed system.

As a long-turn-around one-way technique, the physical exchange of magnetic media is clearly not suited as the primary technology to be employed in the overlay or regional networks where full interactivity is necessary.

3.1.13.1 Description

The use of VCR tapes and related media is one of the oldest and most widespread forms of distance education, but this technique will not be considered as a core technology for the purposes of the instant document. The physical exchange of magnetic media, usually referred to as *bicycling*, can be effective for *off-line applications* (those applications for which immediate response is not required), such as symposium recordings and lectures.

Distribution of magnetic media is usually accomplished in Wisconsin through the manual methods of courier, US Mail or library checkout, although tapes can be delivered to and played at a central location and the signal carried to many endpoints via traditional electronic means.[1]

3.1.13.2 Implementation Considerations

The cost of VCR tape players is very low, averaging less than $500 for a full-featured machine. Blank tapes for local production cost as little as $2.00 apiece, and prerecorded program tapes cost anywhere from $10 to $1000 depending upon program content. These prices makes the exchange of taped materials very cost effective. There are numerous sources where tapes can be purchased or rented, including local libraries, the WECB and the Wisconsin Department of Public Instruction.

Bicycling is therefore a low cost, low technology distance education technique which is well understood by users, and which can be successfully employed to exchange computer databases and even to write books.[2] Many educational multi-media programs are delivered to numerous diverse sites quite effectively in this way today, both in Wisconsin and nationally.

Use of VCR tapes will certainly continue at both the regional and local levels.

Recently, user interactivity with VCR tapes and magnetic disks has been developed which employs a personal computer. It is the opinion of this consultant that such systems represent interim technology since videotape is not a true random access device (as is a laser disc, for instance). This shortcoming results in excessively long retrieval times.

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[1] This type of multipoint use may require a specific copyright agreement. While some uses of copyrighted materials in the distance education environment have been considered to be "fair use" by the courts (such as copying tapes and disks to guard against loss), other uses can be prohibited (such as recording a guest lecture to be used for another set of students at a later time).

[2] Peter Straub and Steven King jointly wrote the book *Talisman* in this manner.

3.1.13.3 Wisconsin Magnetic Media Resources

VCR taped instruction is currently one of the few means by which many Wisconsin students can participate in specialized instruction, especially in school districts without an active educational technology plan. At the present time, the exchange of VCR tapes enjoy the advantages of universal access and broad availability.

As more users get used to two-way interaction, however, use of prerecorded materials will probably decrease.

3.1.13.4 Future of Magnetic Media Technology

At the time a statewide distance education network is initially established, use of VCR tapes will certainly continue to occur at both the regional network level and the educational institution level. In the future, as appropriate and specialized interactive programming becomes more readily available, tape bicycling to the schools is expected to decline due to the lack of immediate interactivity between the student and the instructor. Experience in other states has shown that the availability of two-way video transmission brings an expectation by most users that most off-line programming of the VCR type is just as unacceptable as is computer "batch" processing for desktop PC users.

Because fully interactive video will not be available to the private home until approximately 2015, there surely will be a role for VCR tapes and floppy disks within the network structure well beyond the time its use is discontinued in the schools. In the meantime, VCR tapes and magnetic discs will probably be utilized as a supplemental home delivery system regardless of which technology is initially employed for the local and regional networks, at least until supplanted by optical or solid-state technology.

3.1.14 Summary Technology Analysis: CD-ROMs and VideoDiscs

Since they are functionally equivalent to VCR tapes, CD-ROMs and Videodiscs will not be awarded the status of a core technology for the purposes of this document. The same lack of immediate interactivity with respect to student-to-instructor feedback applies to CD-ROM devices as applies to VCR tapes.

CD-ROM and VideoDiscs are functionally equivalent to magnetic media.

3.1.14.1 Description

CD-ROMs (compact digital discs which contain computer data) and videodiscs (similar discs which contain full motion video and audio, random access video still frames, or multimedia presentations) represent newer technology than VCR tapes, have greater storage capacity, and can be randomly accessed either through the use of fairly inexpensive manual players or exotic computer equipment.

Information is digitally encoded on a plastic/aluminum substrate and is read by a laser in the CD player. Like VCR tapes, CDs and videodiscs are off-line mediums; although unlike tapes they are not generally recordable by end users.[1]

3.1.14.2 Wisconsin CD-ROM Resources

CD-ROM continues to be of excellent use for mass storage, e.g. in library systems.

In Wisconsin, CD-ROMs have found the most extensive use in libraries and other database applications where very large amounts of catalog data must be accessed quickly from many different locations (for instance, the widely used WISCAT computer retrieval system). Obviously, this storage technique is not suitable in cases where the database is extensively changed at very short time intervals; for most suitable applications, however, updates can be accomplished via computer modem downloading or similar means.

Fairly ready access is available to CD-ROM production facilities. Generally speaking, to press 100 copies of a 600 megabit database or video slide show costs approximately $600 to $1,000.

3.1.14.3 Implementation Considerations

In order to utilize this technology within the framework of a distance education network, a player and computer controller are generally required. The player costs between $1,000 and $1,500, while the computer to control the player costs between $2,000 and $5,000 depending upon the capability desired. The disks themselves cost between $10 and $1,000 depending upon content. CD-ROM technology is usually viewed as a low-cost distance education technique.

It is envisioned that CD-ROM and Video-Disc will continue to play important , if peripheral, roles in distance education systems.

It is expected that after a true interactive distance education network is established, CD-ROM disks could successfully be used at both the local level and the network level where they can be set up as database resources, such as a library catalog of distance education programs.

The CD-ROM and VideoDiscs are true *random access devices*. Every location (or frame) on the videodisc can be located merely by moving the read head to the proper angular coordinates along an axis normal (at right angles) to the data stream. This is a far shorter path than rewinding an entire tape. Because retrieval can be made extremely fast, the disc technology is useful for teaching programs

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1. This shortcoming is expected to be rectified within the next five years or so. Tandy has already introduced a "read/write" optical drive for use in distance education, while AT&T has installed "Write Once/Read Many" (WORM) drives in a number of their Unix computers. To date, there have been some fairly serious technical problems with both of these devices, however.

which modify themselves based upon a student's performance or previous knowledge.

3.1.14.4 Future of CD-ROM Technology

It is generally agreed that there will be room for CD-ROMs and discs (or their future solid-state equivalents) even beyond the point where full-scale video interactivity is available to the home, if only to provide additional flexibility concerning playing times.

In fact, computer-based instruction using CD-ROM and multi-media technology may well become one of the fastest growing instructional methods of the next decade, for use in both in-school, and for delivery via distance education technologies. Nevertheless, it is expected that these one-way techniques will be assisted by fully interactive programming.

3.1.15 Summary Technology Analysis of Implementation Techniques: Bandwidth Compression

Compression technology represents the third technology category of *Implementation Techniques*.

3.1.15.1 Description

Compression techniques specify a means whereby it is possible to extend the capacity of most of the above described technologies in order to reduce the per-channel cost of a given set of transportation resources. The net effect of compression utilization is to provide the user with a choice to either employ more channels or to decrease the use of resources (along with the associated costs).

Compression techniques can be used to extend the capacity of most of the previously-described technologies. This is usually done by allowing a signal to be sent through a smaller (less expensive) pipe than is normally necessary.

For example, compression techniques can be used today to transmit two full-motion NTSC video channels via coax, fiber or microwave using the bandwidth associated with only a single channel as recently as two years ago. In addition, the use of compression allows Level 5 teleconference resolution video signals to be sent via readily available DS-1 telephone circuits, thereby accruing only a fraction of the bandwidth costs required by a normal television channel. DS-1 based video systems for use in teleconferencing service have nevertheless seen only limited application to date, in many cases because of an *anticipated* problem with picture quality.

In order to use these techniques, the customer (user) must have access to the bandwidth.

3.1.15.2 Implementation Considerations

The use of bandwidth compression can be a double-edged sword. Although it allows more use to be made of a given amount of available bandwidth, it requires the purchase of expensive coding and decoding equipment. For full motion video applications, interface equipment costs in the neighborhood of $10,000 to $20,000 per terminal. For DS-1 and sub DS-1 applications such as teleconferencing, approximately $20,000 to $25,000 per terminal should be budgeted.

It is important to note that many codecs in common use today utilize a 56 Kbs channel for the transmission of audio. If a total bandwidth of 128 Kbs is available, the picture is actually being compressed into 56 Kbs which is generally considered to be unacceptable by present standards. At a minimum, even "talking heads" should have 128 Kbs available for the picture portion.

In order to make maximum utilization of available bandwidth, flexibility is required on the part of the transportation vendor. Typically, the carrier will offer a lease which does not provide access to the DS-3 multiplexer, thereby limiting the cost savings possible to the user. For the transportation overlay portion of the statewide network, it will be imperative that full access be provided to the DS-3 port on the multiplexer.

The use of 34 Mbs or 36 Mbs for full-motion NTSC signals is also frequently met with resistance from those who fear that some essential data is being "lost". Many of these same people do not realize that 45 Mbs ("high-cap") video, today's acknowledged standard, is already compressed.[1]

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[1] The "standard" TDM data width is a slippery concept, and depends upon the chosen reference frequencies and *quantizing levels*. For instance, if the video reference frequency is taken as 4.3 MHz (the frequency band containing most of the picture), then the *quantizing interval* must be 8.6 Mbs in order to re-create both halves of the waveform. If it is then decided that all possible waveform amplitude levels ("shades of gray" in the picture portion of the signal) can be represented by sixteen (binary word 1111) "quanta", the total TDM bandwidth for the uncompressed signal will be 137.6 Mbs. Other quantizing schemes yield values from 80 to 150 Mbs, all numbers larger than 45 Mbs.

3.1.15.3 The Future of Compression Technology in Wisconsin

The cost of bandwidth as supplied by the Wisconsin inter-exchange vendors on their existing routes is steadily decreasing, with some DS-3s priced at only four or five DS-1s at route locations where existing customers have paid the installation ante. Indeed, in the future it can be expected that the cost of DS-3s will fall much more rapidly than the DS-1 tariffs, which would make the local use of M13 multiplexers economical.

At the same time that compression is being utilized for land-line services, satellite transponders are being configured to pack two, four or even eight TV signals in the space previously required for one. As time goes on, these compression technologies are constantly being improved as computers become faster and the software which runs on them becomes more intelligent; there is consequently no evidence that these advancements will slow down in the foreseeable future. The net result of these anticipated future developments is that more and more information (voice, video and data) may be sent using less and less bandwidth at correspondingly lower and lower costs.[1]

Compression techniques are constantly being improved; this results in higher capacities for a given bandwidth. There is no evidence that these advances will slow down.

3.1.16 Summary Analysis of Other Implementation Technologies

Several other implementation technologies are significant with respect to the establishment of the proposed statewide distance education system. These technologies are described in the Glossary of Appendix S:

There are other technologies and standards which could have an effect on the creation of the statewide network.

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[1] An example may be appropriate here in order to answer the question frequently asked by users: "What am I losing by going to compressed video? Obviously, we can't get something for nothing". The answer is that properly employed and within limits, compressed video can give up very little or nothing at all to its NTSC progenitor, and this fact can be traced to the unnecessary redundancy built in to the existing analog video system. Consider a video scene where two people interact for an extended period of time against a stationary background. An analog NTSC picture must provide every detail of both the foreground and the background 30 times per second even though most picture elements ("pixels") are exactly the same as those sent previously. Using compressed video techniques, the transmission system "realizes" that the background has not changed since its last scan, so it does not bother to send it again but rather concentrates on the portion of the picture which has moved. To provide even greater compression, the codec software can be programmed to make certain assumptions about the moving portions of the picture. For instance, if a person moves from point A to point C in a scene, thereby passing through point B, the compression software may well only transmit the A and C locations and rely upon the receiving codec to calculate the person's position at B.

- SONET: The Synchronous Optical Network Interface Standard. This implementation technology will allow much easier and more extensive access to light fiber by the local networks.
- CCS7: Common Channel Signaling System 7. Although not of direct concern to the telephone system user, this standard will enable multiple vendors to keep track of call origination and charges, thereby enabling enhanced feature groups such as "Caller-ID".
- ISDN: The Integrated Services Digital Network Standard. This standard is being codified by AT&T to provide a unified means of carrying data and voice signals in designated increments and interfacing these increments with their telephone switching equipment from the user's PBX's to the central office:
  - *Basic Rate ISDN* = A data carriage standard of approximately 193 Kbs
  - *Primary Rate ISDN* = A data carriage standard of near- DS-1 rate. ISDN will be available within the next two years in approximately 50 of the largest U.S. cities; this will leave a paucity of service in most of the rural areas. Having been formulated primarily to meet the PBX and data needs of corporations with remote branch offices, video applications are not well addressed by the ISDN standard. Because of these shortcomings, implementation of ISDN as the only distance education standard in Wisconsin would not seem to be wise. On the other hand, ISDN can be carried easily on a DS-1 ensuring end-to-end compatibility for those institutions committed to its use.
- TCP/IP: Unix system data transfer protocol for data networks which is today's standard. May be replaced by the Open Systems standard in the future. DOS networks and Appletalk networks can also use TCP/IP by running a specialized communications or mail program.
- Scanned Network: An implementation strategy whereby all sites receiving downstream programming share the same upstream channel. Scanning software connects each receive site in turn for full-motion display on a single monitor at the instructor's location, usually either in a sequential mode or through the use of a quad split screen. Many applications use a voice-operated switch to lock on to a particular receive location when a question is asked. The use of scanning systems by the regional or local networks poses daunting challenges for the designer of the statewide overlay network:
  - Absolutely identical software would have to be used for all interconnected locations.
  - Nodal control through use of wideband digital cross-connect switches would be vastly more complicated.

- The present voice-activated scanning systems are probably unsatisfactory. Coughing or extraneous noise at the remote receive locations causes lock-up, and the two to four second scan delay on lock-up has been found objectionable by many users. Audio bridging may alleviate this problem, but it has not yet been employed.

The opposite of the scanning mode is the "continuous view" mode which can be accomplished either with separate monitors or with a similar type of screen partitioning whereby all sites are live and on-line at all times.

3.1.17 Ratings Summary Of Technology Alternatives

This diagram summarizes the ratings given to each of the major technologies evaluated in this section.

Technology	Meets Needs			Advantages & Risks			Costs			Migration & Implem			Total		
	Local	Regional	Overlay	Local	Regional	Overlay	Local	Regional	Overlay	Local	Regional	Overlay	Local	Regional	Overlay
Cable TV	4			3			5			4			16		
Coaxial Cable	3			2			5			2			12		
Fiber	4	5	5	4	4	4	1	2	3	4	4	4	13	15	16
ITFS	2			1			3			2			8		
Microwave	4	3	2	4	3	2	4	4	4	4	4	4	16	14	12
Satellite	2	2	2	3	3	3	3	3	3	2	2	2	10	10	10
Telephone Sys	4	4	4	4	4	4	3	3	3	4	4	4	15	15	15

Key:

0 = Does not conform in any respect

1 = Conforms poorly to desired performance

2 = Conforms partly to desired performance

3 = Conforms adequately to desired performance

4 = Conforms very well to desired performance

5 = One of the best options

Summary Of Technology Alternative Evaluation

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The following evaluation provides a summary of the ratings given to the alternative technologies with respect to usage by the three primary network elements.

Analysis of this table reveals that the entire network should migrate so as to utilize fiber carriers in general, and the telephone companies in particular.

During the migration phase, the technologies represented by cable TV and microwave may be used for the local loop, with microwave also serving interim duty for the overlay network.

3.2 Environmental Scan: Lessons Learned From Other States

It is instructive to summarize some of the activities in other states relative to the nationwide efforts to implement distance education systems.

Although distance education has been approached from quite different directions as a result of the technological diversity inherent within the various states, many obvious trends are emerging as a technological consensus is forming. All 50 states are currently engaged in some measure of coordinated distance education planning.

Successful planning for distance education systems, as well as means to incorporate it within an overall *Information Technology* infrastructure, requires a significant paradigm shift in the models presently employed in both administrative and technological structures. Some of the issues requiring re-calibration include:

- Fully compensatory pricing for new fiber installed by regulated carriers promulgated by state utility regulatory bodies.
- Course accreditation and teacher certification issues.
- Acceptance of distance education techniques on the part of students, instructors and administrators.
- Questions of instructor compensation and copyright.
- Proper funding mechanisms.
- Extent of participation by the private sector.
- Training of instructors, users and support personnel.

A number of states have already gone through the process of planning for and/or constructing a statewide distance education system. It would be instructive to briefly describe several of these systems which exhibit pertinent features of interest with respect to Wisconsin's needs, and to point out some of the lessons which have been learned from their experiences.

The summaries which follow have been obtained from reliable publications specializing in distance education. In the cases of Indiana, Illinois, Michigan, Minnesota and Ohio, published information has been supplemented by the direct experiences of this firm.

3.2.1 Overview of Selected Distance Education Systems

3.2.1.1 Iowa

Iowa is currently installing a two-way interactive video system employing a completely state-owned fiber system for the backbone. The fiber backbone interconnects every county seat and provides two-way interactive communications at these "regional nodes". The State Department of General Services has designed and is managing the backbone system, called the Iowa Communications Network (ICN). This backbone has a capacity of 12 DS-3 links and interconnects with an extensive ITFS last-mile network which has been built up over the last 10 years. The ITFS portion of the network employs transmitter sites at nearly all major population centers; the ITFS system is typically paid for and managed by the local institutions. The ITFS network is configured to cover most of the state K-12, VTAE, and college institutions with at least two channels of downstream full-motion video.

Iowa is installing a statewide, state-owned fiber network which will provide two-way capability to every county seat.

This network will have a 12 channel capacity and will connect to local ITFS networks.

Ultimately, plans call for a 2,000 mile fiber optic backbone connecting the three Universities, 15 community colleges and all K-12 institutions in Iowa's 99 counties.

All educational institutions will also be on the network.

The Iowa system has been the subject of extensive controversy as well as several lawsuits. Because the carriers were by-passed for the most part, Iowa did not make use of in-place resources in the construction of the network. Consequently, the system may have cost somewhat more than it could have if at least some portions of the overlay network were to utilize existing common carriers. In addition, the State of Iowa has put itself in the position of syphoning revenue from private companies. There has been some discussion recently concerning privatization of the network.

Iowa did not make use of existing resources, thereby increasing the cost and creating ill will with the common carriers.

As far as the network topology is concerned, the Iowa model has much to recommend it. Although initial fiber construction to every county seat may be overkill, the use of ITFS as a migration path to full two-way interactive fiber connections is a valid concept which could be expected to work in Wisconsin as well.

3.2.1.2 Illinois

The State of Illinois represents a stark dichotomy in distance education capability. On one hand, the state enjoys extensive resources as numerous high-tech companies have interconnected their facilities using the impressive statewide capabilities of AT&T and Illinois Bell. Many local, technical, and 4-year colleges, such as the

Illinois has extensive local and regional networks, but to date has made little progress in bringing them together into a statewide system.

College of DuPage, Northwestern University, Bradley and the Illinois Institute of Technology are constructing integrated video/data/voice remote campus links, as well as workplace education business partnerships (such as NetIllinois).

On the other hand, there is to date no successful effort to centrally manage wideband resources at the state level. Initially, most local solutions are vendor driven, although the Illinois Board of Higher Education is in the process of establishing standards for a T-1 interconnect. Although authority to design and begin construction of a statewide distance education system has been vested in the Telecommunications Bureau of the State Office of Central Management Services (CMS), progress has been very slow primarily because of a demonstrated unwillingness to build coalitions with existing consortiums. In addition, separate networks are presently being established for data use and for compressed video use, reflecting a pervasive inter-agency jealousy.

As a further complicating factor, the Illinois Department of Education has divided the state into several "service agency" regions for purposes of funding. These regions have split several existing consortiums, making cooperative effort even more difficult.

As several regional networks reach their capacity, the realization that statewide planning is needed is increasing.

For the most part, inter-institution cooperation is very rare in Illinois among educational entities, with one partial exception.

There exists a loosely knit consortium of educational institutions located in the central and southern portion of the State of Illinois which manages an extensive video/data/voice microwave interconnect system serving the regional Universities, Colleges, Technical Schools and private employers. This system is also used as an educational TV interconnect, and has worked well for the past 15 years.

Recently, the demands upon the microwave system have stretched its capability to the limit, until the point has been reached where additional requests can no longer be accommodated by the analog microwave technology in use. Because the consortium has not been configured with either the focus or the authority to undertake the required planning and migration studies, they can only react to crises as they occur, causing wasteful bandaid solutions to be applied. This assures a non-optimal allocation of resources and a perpetual state of inadequate capacity. Many of the member institutions are going outside the consortium for their electronic transportation needs, leading to duplication of effort. Several of these same institutions are suspicious of granting the consortium more authority, since they assume other competing institutions may obtain a disproportionate share of the advantages.

Recognizing these shortcomings, the consortium leadership has recently begun a consensus building process which may soon culminate in a statewide capacity study.

Several consortiums have made significant progress in establishing governance structures (such as the Western Illinois Education Consortium), which may indicate that the Illinois distance education model may soon reach critical mass and move forward in an expeditious manner.

3.2.1.3 Indiana

The State of Indiana's Higher Education Telecommunications System (IHETS) was constructed on behalf of the state's higher education institutions (both 4-year colleges and technical schools) and dates to 1980. The system consists of a fiber optic 16-node backbone feeding signals to an extensive statewide ITFS system which reaches more than 250 receive locations. The ITFS system has a capability of 8 to 16 multiplexed TV channels covering nearly every community in Indiana, while the backbone delivers four frame-multiplexed channels statewide from a switching center in Indianapolis. The fiber backbone is provided by GTE-Telcom Indiana and capacity on this fiber is leased by a quasi-public system integrator dubbed the Intelenet Commission. The original purpose of the Intelenet Commission was to assure a steady demand for services by reselling capacity to various state government agencies. IHETS currently leases video and audio transportation services from Intelenet at a fixed rate. There have been some cases of Intelenet competing for business with IHETS within the educational community; at the same time, there has been virtually no usage of the Intelenet/IHETS system by state government.

Indiana has had a network connecting its colleges and universities since 1980.

A fiber optic backbone feeds regional ITFS stations; return audio is provided through a private state telephone network.

Over the years, the IHETS system has been extended to cover VTAE remote campuses (such as the IVY Tech satellite locations) and many K-12 institutions. IHETS offers nearly 200 hours per week of programming.

Interactivity is accomplished at the last mile by using audio return to the instructor via the private state telephone network called SUVON. SUVON also uses the GTE fiber backbone and a dedicated partition of the GTE Northern Telcom switch located in Indianapolis. The audio return system incorporates computer-based equipment developed by IHETS which queues the calls coming upstream to the instructor and presents a graphic display of the waiting inquiries along with their origins. Full DS-3 level two-way video is presently employed primarily outside of the IHETS network on an "ad hoc" basis (such as between Purdue at West Lafayette and Indiana University at Bloomington).

Future enhancements will allow the major universities to have two-way video capability. Satellite use and a data network are also being implemented.

IHETS is presently working on system enhancements which will allow the primary universities such as Indiana University, Purdue and Ball State to have full motion two-way capability along with DS-1 compressed teleconferencing as part of the IHETS network. At the same time, satellite technology is being implemented in order to reduce the load on the backbone through the use of compressed satellite channels and an existing uplink at Indianapolis. The addition of a data network is being explored which would provide interconnection at DS-0, DS-1 and DS-3 rates in the future, and would also enable full two-way video as far as the ITFS sites.

As the current Intelenet contract expires, IHETS is negotiating with Intelenet to explore the possibility of a "demand bandwidth" basis for system pricing, whereby IHETS would only pay for the resources they actually use. IHETS has the requisite technical expertise to dynamically allocate their own bandwidth, thereby making the movement of the Demarc to the vendor's side of the multiplexer a logical choice.

Indiana's network has succeeded mostly because of advanced planning and excellent institutional cooperation.

Indiana's distance education system has been highly successful primarily because of a willingness to plan ahead, the cooperation of the individual institutions with respect to central planning and the willingness to implement those plans before they become obsolete. On the other hand, the "broadcast" nature of the technologies used (ITFS, satellite, and the fact that nodal switching is not available on the fiber network) will slow down the development of full-implementation two-way video, especially since the institutions are very adept at using the existing video/SUVON system.

3.2.1.4 Michigan

Many local and regional consortia in Michigan have been active in establishing distance learning networks in the past several years. Most of the two-way interactive networks being planned or implemented are fiber- based systems utilizing analog FM technologies. Michigan Bell is currently making available a 16 channel distance education system in a few of its metropolitan service areas such as Lansing.

At the same time, the Michigan cable industry is also actively working with local K-12 school consortia in partnering arrangements. In a typical agreement the schools pay for fiber cable (usually eight strands) and the cable company installs it along with their own fiber cable as part of a general system upgrade. The schools own and maintain the electronics associated with their fiber (the *Fiber Optic Terminal Equipment*, or FOTs) while the cable company performs all maintenance and repair on the fiber itself. This partnership arrangement has worked very well in Michigan, and the technique is spreading to Ohio as well.

The higher education community in Michigan seems to be favoring DS-1 and fractional DS-1 video techniques at the present time.[1] There is also some use of satellite services related to the Satellite Educational Resources Consortium (SERC).

On the regulatory side, the Michigan Telecommunications Act was recently passed by the Michigan state legislature. This Act is considered by many knowledgeable persons both within and outside of the telephone industry to be a very progressive step in the encouragement of distance education technologies. It is expected that the act will benefit the public because it allows more competition with less regulation. In response to the Act, the Public Service Commission in Michigan has given approval to Michigan Bell and the telephone industry to price educational video services according to a new format. This format follows a bandwidth pricing mechanism as opposed to the traditional compensatory cost allocation process. This will allow the providers to anticipate demand for services in the laying of new fiber, thereby not requiring that the initial users of leased facilities pay the entire cost. The State of Tennessee has also modified its regulatory structure along this same model.

Michigan has been very active in creating two-way fiber-based distance education systems. Michigan Bell and the cable companies have been very active in these efforts.

Michigan recently enacted laws which allow more competition and less regulation on the part of the carriers. They have thus solved one of the primary problems faced here in Wisconsin.

Michigan Bell has extensive fiber optic facilities in place and will have over 200,000 miles of fiber installed by the end of this decade. An attempt is currently being made to design and ultimately construct a statewide overlay network which would consist of a digital fiber backbone interconnecting analog local loops.

3.2.1.5 Minnesota

The State of Minnesota is currently in the process of creating the State Telecommunications Access and Routing System (STARS). STARS will be a statewide fiber optic network with adequate bandwidth to handle both the video and data needs of the educational institutions in the state, along with their business partners. STARS is managed by an advisory board comprised of five members from state agencies and five members from the educational community.

The main purpose of the STARS system is to interconnect the existing regional networks. There are approximately 31 such regional networks in operation throughout the state, most of which utilize analog technology and have been in operation for some time. These networks are comprised of consortia serving the

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[1] Paradoxically, many research-oriented Universities which are not extensively using two-way video appear to favor DS-1 and 192 Kbs ISDN solutions for integrated interconnects. This may be because the people who are driving these selections are associated with the data department. This consultant knows of no case where such bandwidths have been acceptable to video programming people for credit course delivery for even the short term.

University of Minnesota, technical colleges, independent colleges and selected K-12 schools. Much like Wisconsin, the existing networks incorporate a wide range of technologies: fiber, coax, microwave, ITFS and satellite.

Minnesota is in the process of creating a statewide, fiber-based video and data network which will include educational institutions and business partners. This network 's main purpose is to interconnect regional networks.

Designers of the Minnesota network plan to provide two basic kinds of service:

- Wideband Video Service (45 Mbs or DS-3): this service will be used to deliver and receive two-way interactive educational video programming to and from the regional networks.
- Video Conferencing Service (384 Kbs or less): this service will utilize bandwidth compression techniques to conduct two-way interactive video teleconferencing services.

3.2.1.6 Mississippi

The State of Mississippi has created a network called MS 2000. MS 2000 is a unique public/private partnership whereby an allocated portion of the network construction cost was underwritten by the state public sector as well as the business community. MS-2000 represents a laudable joint effort:

Mississippi has entered into public/private partnerships to establish both a statewide fiber network and a statewide ITFS network.

- Mississippi Authority for Educational Television.
- Northern Telcom.
- South-Central Bell.
- Bell South.
- Apple Computers.
- Mississippi State University.
- Mississippi School for Math and Science.
- IBM.
- Various K-12 districts.

The MS 2000 distance education system was the first to use a public switched broadband network with digital fiber as the transmission medium. The network currently connects eight locations in the state including high schools, universities and an educational TV station.

South Central Bell has provided the fiber, multiplexers and network terminals. Northern Telecom has provided the codec and classroom video equipment, while the Mississippi Department of Education has provided the classroom monitors and cameras.

Mississippi has also recently entered into a public/private agreement to create an ITFS network which will cover the entire state.

Although the particular technology choices made by Mississippi may not be appropriate for Wisconsin, the spirit of cooperation among the educational institutions, the state government and private business represents the ideal environment within which distance education systems can grow and prosper.

3.2.1.7 Kentucky

Because of a state supreme court decision finding Kentucky's school funding mechanism unconstitutional, the state has embarked upon an ambitious program since 1989 to utilize distance education technology to equalize access to education throughout Kentucky.

The Kentucky Educational Television Authority (KET) has been created to plan the distance education network to be used by the state's K-12 and higher education institutions. Under an explicit agreement, KET provides the conduit, while the Kentucky Department of Education (DOE) provides the programming content.

Kentucky is currently planning a statewide system which will include all educational institutions.

3.2.1.8 South Carolina

The South Carolina Education Television (SC-ETV) provides nearly all educational programming originating within South Carolina. Programs are produced under guidelines prepared by the Department of Education (DOE). The SC-ETV network provides more than 150 hours of programming per day, most of which is destined for higher education purposes.

SC-ETV programming is carried on 11 television stations, 8 FM stations and an extensive ITFS and two-way microwave system which provides at least two video channels and one audio channel to slightly over one-half of the state's 630 schools. A satellite program is also being implemented to supplement this existing network with 25 digital video channels.

South Carolina provides a great deal of programming to about half of their schools using TV, FM, ITFS, satellite and microwave.

3.2.1.9 Washington

The State of Washington is currently embarking on a hybrid light fiber and microwave project to form a statewide distance education overlay system (WHETS). This effort should be closely monitored because it parallels the recommendations which are being made for Wisconsin.

Washington state is creating a network much like that recommended by this study.

3.2.1.10 Ohio

Ohio is just beginning to plan a statewide system based on fiber.

Much of the impetus for distance education in Ohio originates in the very rural and relatively poor southern section of the state known as the Appalachian Valley. The Ohio Valley Regional Development Commission (OVRDC) has coordinated a sequence of grants, loans and engineering studies which has resulted in an embryonic light fiber system which is steadily expanding east from Cincinnati, south from Chillicothe, west from Athens and north from Portsmouth. Ohio University is planning to interconnect to this system, and Ohio Bell has announced its "Ohio Plan" which would provide last-mile fiber to all schools in the state which Ameritech services. GTE similarly is encouraging educational use of wideband communications; for example a new network is being built near Lima. The nodes of these networks are primarily the state's *Joint Vocational Schools* (JVS), each of which services an area approximately the size of a county. The Ohio distance education effort demonstrates that a few dedicated people can overcome limited resources in order to establish an equal-access educational infrastructure.

3.2.2 Conclusions for Wisconsin

It is clear from the above that fiber is the dominant technology, and that a technology mix can be used to serve the local user.

It is clear from the above environmental scan that digital light fiber is the dominant technology for nearly all recently designed state overlay networks. A mixture of point-to-point microwave, ITFS, CATV, telephone carriers and satellite technology is being used to serve the last mile (regional and local) role. Of the systems similar to Wisconsin's in scope, wide-band two-way video capability is the technique of choice.

Several states are revamping their Public Service Commission regulations to allow educational-use fiber systems installed by regulated carriers to be initially priced in a manner which is not initially fully compensatory. Wisconsin is presently facing this same issue with respect to the Urban telephone case.

There are several benefits to state involvement in network creation.

Although switched wide-bandwidth services will eventually be available to nearly all educational institutions by the year 2015 even without state guidance and funding, the environmental scan makes it clear that some state-level management and guidance is required in the establishment of the overlay network in order to avoid the pitfalls of "ad hoc" network development:

- State involvement would be necessary in order to assure equality of educational access throughout Wisconsin during the network construction period.

- State involvement would be necessary in order to encourage the setting of standards so that developing regional networks are compatible with each other.
- Individual users and consortia managers will require an information and assistance resource in order to cope with the various esoteric aspects of distance education systems, such as network design, training of personnel, and negotiation with vendors.
- State involvement would be necessary in order to ensure that facilities are not duplicated, and that the building of the network proceeds from nodes which are cost-effective from an overall utilization standpoint.
- The state's buying power would be necessary in order to keep costs low (the successful STS system with its $0.05 per minute call rate is evidence of this).
- State involvement would be necessary to ensure network planning takes all potential users into account.

Similarly, in order to have the best chance of success, maximum participation and support would be required by every affected entity:

- State agencies.
- State businesses.
- Colleges and universities.
- All Vocational Schools.
- The Private Schools.
- The maximum number of K-12 districts.

The best chance for success lies with participation by all.

Wisconsin spends approximately $1,217 per capita per year for education, which is somewhat more than the U.S. average of $1,063 but is below such states as Wyoming, Vermont, Minnesota and Michigan. If an additional $10 per capita were available, and an appropriate regulatory environment was in place, Wisconsin's five million residents could purchase a complete educational backbone system to be installed over a 12 year period.

An additional $10 per capita per year could fund an educational network backbone.

Periodically, questions concerning the effectiveness of distance education techniques are raised. This topic has been explored rather extensively in *The Effects of Distance*

Learning: A Summary of Literature.[1] Most of the comments support distance education concepts in the vein of the following selected examples:

- "Distance education programs are effective in providing educational service to those who would otherwise be unserved."[2]
- [Distance education results in] "higher cooperation, [and] communication between schools and districts, [as well as] parental involvement with courses."[3]

The next four bienniums provide a window of opportunity to ensure that an overlay network could be developed in an orderly way, and would be most cost effective for the residents of Wisconsin. Lack of action will leave these important resource development decisions in the hands of people who have a much narrower focus than the best interests of the state.

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1. Research Monograph, 1990, American Center for the Study of Distance Education, the Pennsylvania State University.
2. Eiserman and Williams, 1987, Pages 7-13.
3. Batey and Cowell, 1986.

4. Means Of Responding To Needs

4.1 Alternatives for System Construction

This section of the document will recommend the appropriate technology which should be employed for each of the three major network elements, and will present possible frameworks for implementing them.

This chapter will recommend technologies and implementation frameworks for meeting the identified needs.

4.1.1 Dismissed Implementation Alternatives

In considering which technologies to use for the three distance education network components within Wisconsin, it is important to remember that all of the technologies outlined in the previous *Alternatives* section are already in use to some degree in this state. Therefore, it would be irresponsible to recommend that any one of the in-place technologies should play no role in the future development of the local, regional, or overlay networks. Conversely, it is likewise impractical to utilize one technique exclusively with no thought given to appropriate migration.

Nevertheless there are some alternative uses of several of the studied technologies with respect to one or more of the three main system components which can be summarily discounted. These alternatives and the explanations for the discounting are given below.

Some alternatives have been dismissed as not feasible or desirable.

4.1.1.1 New Entirely State-Owned System

Constructing a completely new state-owned system, along the Iowa model, is undoubtedly not a viable alternative for the State of Wisconsin. In addition to being prohibitively costly, executing this option would duplicate facilities and other resources already in place. It would also take business away from the private sector without a corresponding public benefit. There are a sufficient number of competing inter-exchange carriers, mature regional distance education systems, and other resources (both state-owned and privately owned), so that complete bypass of existing information technology transportation vendors is neither desirable nor necessary.

Constructing an entirely new, state-owned system would be very costly and would bypass existing providers and existing resources. It would be inconsistent with prior state efforts.

In any case, building a completely new network is contrary to the stated direction Wisconsin has been taking with similar past efforts such as the STS telephone system and the CDN computer network, both of which are managed by DOA/BITM and which lease capacity from AT&T. An entirely state-owned approach would also usurp the ability of local network developers to make their own decisions concerning technology and timetables, a condition which runs counter to strongly enunciated requirements as reported in the *Needs Assessment*. The need for allowing local planning and technology flexibility was seen both in this study and prior studies as well.

Establishment of the three distance education system components, namely the overlay network, the regional networks and the local networks, dovetails well with a shared state/local responsibility scenario. Ideally, the State of Wisconsin would be responsible for the overlay network to the remote campus level (Tiers 1 and 2), while planning and financing responsibility for the local and regional networks would fall to the local consortia. It is expected that an appropriate agency of the state would provide guidance with respect to standards and techniques for these local networks.

Dark fiber is not available in Wisconsin. Also, this method would require the purchase of very costly equipment and would raise service issues.

4.1.1.2 Use Of Dark Fiber for the Transportation System

Buying or leasing "dark fiber" can be among the most cost-effective ways to construct large-capacity fiber optic cable systems. As a practical matter however, obtaining immediate access to dark fiber for backbone use is neither likely nor necessary in the case of the Wisconsin network. When asked, every one of the common carrier fiber providers was adamant that leasing of dark fiber by the state is not an option for backbone transportation at the present time. Since such a request is tantamount to asking the vendor to turn over his raw resource, this is not an unreasonable position to take, at least in today's environment.[1] In the future when fiber is more generally available, the matter of obtaining dark fiber should be re-visited. It is partly for this reason that long-term leases for high-bandwidth services should be avoided by the state and user's consortiums alike.

Another problem associated with dark fiber is the fact that extensive and expensive terminal equipment must be purchased by the user. This equipment requires an extremely high level of expertise to specify, install, manage and maintain. At the present time, there is no provision within any state agency to assign personnel to such a task. Therefore, equipment and services would have to be purchased from outside suppliers which would substantially negate any advantage obtained.

The above facts notwithstanding, some local cable companies appear willing to provide dark fiber to schools and other local businesses and institutions. However, these opportunities would generally be available only to those communities served by local cable companies which employ light fiber, and which are usually located in the larger urban areas. Even so, the cost of equipment to illuminate the fiber would probably be cost effective only for relatively large users such as colleges and hospitals, even assuming that analog multimode cable was employed.

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[1] In the case of GTE, some of the fiber cable utilized contains only four fibers. Turning over one pair would mean that 50% of their capacity would be lost.

4.1.1.3 No Statewide Initiative

Any discussion of alternatives is not complete without an exploration of the alternative of "doing nothing". The "do nothing" alternative is emphatically not recommended.

In the case of the Wisconsin distance education network, not implementing a statewide initiative of some description would mean that local systems would develop and expand at their own pace as funding permits, forming a patchwork quilt of overlapping service areas and incompatible standards. Eventually many of these systems would be interconnected and a de facto statewide network would develop. However, there are several serious problems with this approach:

- First and foremost, this approach will in all likelihood result in the largest portion of the needs identified by this study going unmet within the ten-year planning horizon, since each local consortium will have to ramp up the same learning curve.
- Without state planning and some funding, it is unlikely that local systems could grow to cover the major parts of the state with a relatively low population density. This would perpetuate the unequal access to educational resources currently troubling the smaller school districts.
- Because of a lack of standards, there is a virtual certainty that incompatible systems would develop, resulting in wasteful effort expended in interfacing these systems. Cross-system teleconferences would be difficult to arrange, technically unstable, hard to manage by the user, and prone to failure (lack of *transparency* from the user's perspective).[1]
- Similarly, because of a lack of coordination, some systems would necessarily overbuild parts of others, resulting in a duplication of effort and a waste of resources.
- Because of the lack of a central clearing house for expertise, most local and regional networks would make many of the same implementation mistakes. Vendor-driven solutions would predominate, leading to higher costs.

The "do nothing" approach would result in most of the identified needs going unmet. It is likely that incompatible systems would be created, and costly duplication of resources would result.

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[1] The necessity of statewide standards cannot be overemphasized. Even now, it will be difficult to interconnect many of the local networks employing scanning technology, and some functionality is sure to be lost for inter-network transportation.

- Staff development courses would be sparse for instructors at remote campuses, at least for an extended period of time. This may reduce the quality of education for a complete generation of students.
- Confining growth to local systems development would be less cost efficient than the purchase/lease of statewide facilities which could amortize the cost of a system over a larger number of users. This would result in a higher cost per drop to the individual school. In addition, the state has a higher degree of purchasing power, can obtain more favorable rates and terms, and can negotiate effectively with other regulatory agencies such as the PSC. Moreover, the state possesses some existing resources such as tower sites and microwave systems which could be of considerable technical and financial benefit as part of a statewide system migration plan. This specific point will be examined more fully in the migration chapter of this document.

4.1.2 Recommended Technologies and Implementation Framework

4.1.2.1 Introduction

4.1.2.1.1 Background

Given the needs identified in Chapter 2 and the technology choices identified in Chapter 3, the purpose of this section is to make recommendations on how to employ the most serviceable technologies effectively in order to create a network which meets user requirements. Full cognizance will be taken of the experiences of other states in these determinations. These recommendations will be followed by the benefits to be derived from the recommendations, and the unresolved issues which must be addressed.

As previously mentioned, the common needs expressed by each of the major educational user groups centered on two principal issues: the need to equalize educational opportunities for all students, and the need to provide improved access to professional development courses and programs for faculty and staff. In terms of network administration, a continuation of the past Wisconsin practice of "the state provides the conduit for the overlay network, but the users provide the content" is assumed.

4.1.2.1.2 User Considerations

Most of the users who have provided ongoing input for this study have similar thoughts on how these basic needs should be met. First and foremost, they wished to be able to provide improved educational opportunities to students within their own educational systems, institutions or districts through the use of locally managed systems. Secondly, they wished to network with other institutions within their major geographic group in a compatible manner. Finally, they wished to network with other major user groups, businesses and hospitals to form partnerships.

As an example of this topology, the first priority of many VTAE institutions is to establish connections with its branch campuses; the next priority is to connect with the other VTAEs throughout the state, and the next priority (although frequently tied with priority number two) is to establish network connections with other district institutions such as high schools.

Many of the needs expressed by major user groups had a corresponding "mirror-image" need expressed by another affected group. For instance, the VTAEs would like to network with high schools, and the high schools have also expressed interest in networking with the VTAEs. It is extremely important that such bi-directional support be encouraged in order to avoid the sense of disenfranchisement which frequently occurs when a system is up and running at one institution while opportunities are limited for others in the same area.[1]

4.1.2.1.3 Synergies Due To Consolidation

A network to satisfy all of the needs expressed by each major user group would undoubtedly result in much duplication of facilities if separate networks were built and individually controlled by the disparate interests. Such duplication would not be cost effective. Instead, it is entirely feasible to combine the needs of all users, including the Wisconsin agency users, into a single network consisting of individual network clusters interconnected by a statewide overlay network. Each individual network cluster would satisfy the particular regional and local needs of each user group while the statewide overlay network would help to satisfy the common needs of all groups for statewide access to facilities and resources in the three functional

If major user groups created networks to meet their individual needs, much duplications of facilities would result.

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[1] The Wisconsin ITFS system, in the view of some K-12 systems, was the source of such disenfranchisement when systems were constructed by VTAE Colleges a few years ago. In some cases, local K-12s were given the option to participate early in the planning process, but they declined. In other cases, a more extensive effort might have been made on the part of the local VTAE to acquaint the district schools with the benefits of ITFS technology. In any case, once the technology was in use and its utility could be perceived by all, some resentment formed on the part of the "left out" schools which exists to this day.

areas of video, data and voice. An analysis of the combined needs of all users clearly points to a network that could ultimately encompass the entire state.

4.1.2.2 Technology Recommendations

Given the user considerations detailed above, the following technology recommendations are presented for each of the three primary network elements - the local networks, the regional networks and the overlay network:

4.1.2.2.1 Local Networks

Local users usually have the greatest number of technology choices.

Local networks serve to connect individual institutions within a relatively small geographical area such as a community school district. If a VTAE facility, UW college campus, library, hospital, pertinent business or CESA office were located within the area served by the local network, it could also be included in the local network topology.

In the short term, any of these technologies can be cost effective. In the long term, it is felt that only the cable option and the local telephone utility option will be viable.

The determination of which technology to use in the local network depends on several factors, the most important of which are cost and availability of facilities. Local users, alone among the users of the three network sub-systems, usually have a cornucopia of choices concerning which technology to employ:

- Point-to-Point Microwave.
- ITFS.
- Local Exchange Carrier.
- Cable TV Company.
- Satellite.

Any of these technologies can be cost effective for the mid term. However, subsequent to the year 2000 the demands upon the local systems will be such that essentially only two choices will remain:[1]

- The Local Exchange Carrier (telephone utility).
- The Local Cable Company.

The local exchange carrier (LEC) will usually prefer an all-digital fiber solution while the local cable company will usually offer an analog fiber or coaxial cable solution. Both systems will work equally well in the local loop, and the choice should be made based upon cost and terms. However the individual advantages and disadvantages of each technology, as outlined previously, should be kept in mind to ensure that the proper reliability is obtained and that lease terms and capital equipment costs are compatible with the all-digital fiber network expected by the year 2015 (it is likely that as the demand increases, the cost for the last mile digital fiber systems will be competitive with the analog systems).

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[1] The crystal ball has become somewhat clouded by the February 1993 Ameritech announcement that it would file with the FCC for permission to enter other businesses in return for an elimination of the local Ameritech monopoly. If enacted, this would undoubtedly increase the number of companies supplying local telephone services.

In summary, because they are smaller in size and tend to be the least expensive (from a total dollar outlay perspective if not on a per-institution basis), local networks have a wider selection of technology choices than other elements of a statewide network. Technologies that are recommended for local network applications, in the approximate order of desirability are:

- Local exchange carrier fiber (analog or digital).
- Unregulated carrier.
- Cable TV system fiber or coax (analog or digital).
- Point-to-point microwave radio (expansion of existing facility).
- Point-to-point microwave radio (new construction).
- ITFS (limited two-way video).
- Satellite (occasional one-way video use).

Local networks are most likely to be implemented with whatever technologies are economically available, and that includes ITFS and point-to-point microwave in addition to the offerings by the cable and telephone companies. Current cost estimates suggest that analog fiber systems in the local loop might be the more cost effective technology where it is available, followed by microwave and then a digital codec system.[1] For limited two-way video applications, ITFS is the most cost-effective technology of all if multiple end points must be reached.[2]

4.1.2.2.2 Regional Networks

Regional networks serve to interconnect more geographically dispersed clusters of users. Most of the educational networks presently being implemented or proposed in Wisconsin are regional networks. These systems tend to be inter-community in nature and can span many miles, crossing several county boundaries and LATAs. Node control switching points (using digital cross-connects and video switches) on

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[1] Digital fiber is closing the cost gap with respect to other technologies. Recent RFQ responses have yielded costs which are significantly lower than those obtained only a year ago.

[2] It is the opinion of this consultant that most ITFS systems which are currently on the drawing board *should be built* if a recent business case has been made for them. They should be able to be amortized before they will no longer be required (currently estimated as the year 2015 for most of Wisconsin).

Technologies recommended for regional networks include fiber, microwave for certain endpoints, and ITFS for one-way applications.

the regional networks would serve as the interface point between the regional networks, the local networks and the overlay network. Through this arrangement local networks could access any location on any regional cluster on a statewide basis. Technologies that are recommended for regional network applications are, in the approximate order of desirability:

- Local and inter-exchange carrier fiber.
- Unregulated carriers.
- Point-to-point microwave (limited endpoints only).
- ITFS (limited two-way).

Some existing regional networks use cable TV systems. These systems are not ordinarily recommended for regional networks because of the very limited availability of facilities on an inter-exchange basis, as well as the problems associated with maintenance, distributed responsibility and multiple interfaces.

Capacity and conformance to standards are important issues for regional systems.

The primary requirement for the regional networks is that they have sufficient bandwidth and compatible technical standards to accommodate the multiple video channels demanded by the local networks, and that they have the capability for carrying voice, video and data traffic over the same facilities. Because of these technical requirements, and because of the long distances which may exist between isolated interconnected sites, it is felt that digital fiber optics is the best choice for regional network backbones if it is cost effective. A supplementary and migration role would be appropriate for point-to-point microwave and/or ITFS in many individual cases where fiber systems are not economically available or where distance and other factors prevent the use of fiber. Existing microwave systems could also be used on other portions of the network where channel capacity is not a limiting factor. Appendix E-1 is a diagram of the DOT microwave system which could be very effective if used for some of the interconnect tasks.

ITFS systems are also classified as regional networks because they are most often used to broadcast to sites over a 20 mile radius, and to interconnect individual systems between 25 and 40 miles distant using ITFS Inter-City-Relays (ICRs). These systems will serve an important early role in distance education as the migration to fiber systems continues. The emphasis in the next five years should be to enhance existing ITFS systems for full two-way video interactivity and to expand existing systems to reach a wider range of users. Since ITFS technology is channel limited and is not an effective media for voice and data transmission, it is not well suited for certain network segments of the regional networks. ITFS systems may well be required to supplement other technologies within the migration period. Nevertheless, in most cases in Wisconsin, funds expended to add channels and capacity will continue to bear fruit even after the overlay network arrives by providing a flexible "off-net" video connection available to everyone in the service area.

4.1.2.2.3 State Overlay Network

For the overlay network, a switched digital system using fiber and supplemented by microwave is recommended..

The State Overlay Network would conceptually serve to interconnect multiple clusters of independent regional networks. The overlay network must ultimately provide service to all users in the state and must meet a wide range of criteria as concerns capacity and availability (see Section 4.2, "Required Features of a Statewide Network"). To meet these criteria, a switched digital network is required which is centrally managed. Both fiber optic and microwave radio systems can be used for this network element. Existing analog microwave segments could be used today where fiber is not available and where channel capacity is not a problem. These segments could later be converted to digital microwave and ultimately to digital fiber when economics dictates.

The overlay network must provide a wide range of services and must have significant capabilities.

Migration to an all-fiber overlay network could be accomplished using existing microwave systems to provide redundancy and route diversity for some segments of the network. Such reliability may well be required to convince some computer data users and other high-reliability applications to trust the network.

Microwave may also have a role in the future statewide distribution and interconnect of broadcast television and FM radio, as discussed earlier.

To interconnect regional clusters to the overlay network would require a node control point where the two networks meet; these nodes would be similar to the node control points established between regional networks and local networks. The main functions of these nodes would include the following:

- To ensure that the overlay network does not impede traffic on the regional networks or use capacity on the regional or local networks which is required to carry local signals. The node control point would provide some level of network switching and control to "off load" traffic which does not require transportation on the overlay network.
- To provide an interface between equipment which may have dissimilar operational and technical parameters.
- To provide cross-connection between regional networks so that all traffic does not have to be handled by one central switch.
- To provide a single location where capacity can be added, redundant routes can be connected, and local inserts and drops can be performed.

The overlay network must be capable of transmitting both wide-band video signals (via SONET DS-3s) and reduced-bandwidth video, voice, and data (via DS-1 facilities and ISDN included as DS-1s). The network would consist of both switched and dedicated facilities. Ideally, the network manager will track traffic so that dedicated facilities can be purchased from the carriers or from the system integrator, but switched services can be made available to the users without sacrificing efficiency.

Some of the larger users may have a need to be able to dynamically control the amount of bandwidth they need to accommodate frequently changing local conditions. For these users special equipment would be necessary, as well as special arrangements with the system integrator for shared responsibility. All levels of the network will be password protected so that only authorized users will have access to pertinent traffic routes and schedules.

4.2 Required Features of a Statewide Overlay Network

This section outlines the required features of a statewide network.

In previous sections, this document has reviewed all pertinent technologies and recommended which should be used for the three distance education network elements, as well as under what conditions they should be utilized. The following section provides a set of attributes which should be present in any statewide overlay network created through the means outlined above, based upon user interviews and the experience of this consultant.

4.2.1 Feature #1: Available To All Users At Reasonable Cost

The most important feature of a statewide interconnection system is that it be universally available to all potential users at a reasonable cost. Additionally, the system must be flexible enough to meet the changing needs of its users. Users should never be forced to use a system that does not meet their specific operational and budgetary requirements. The *Needs Assessment* phase of this project indicated that the total amount of money available at the institution level for information technology transportation purposes is approximately $1,000 to $2,000 per DS-3 per institution per month. This would be the net cost after savings due to data circuit consolidation.

4.2.1.1 Overlay Network Structure

The structure of the overlay network should consist of three components:

- The main high-capacity transportation trunk interconnect loop, containing route redundancy [*Tier 1*].
- The secondary medium-capacity star node links to reach regional switching locations [*Tier 2*].

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- The feeder circuits to interconnect regional and local networks [*Tier 3*].

Each of these overlay network components has a unique role in consolidating and managing Wisconsin's investment in information resources, as discussed below.

4.2.1.2 Management Structure

The management of the statewide overlay network should consist of the following elements:

4.2.1.2.1 System Integrator

The job of the system integrator would be to assemble all state requests for information technology bandwidth and acquire the appropriate capability from vendors through the RFP process. STS, CDN, Wiscnet, the lottery network and uses by DOT, DNR and other state agencies are anticipated. Ideally, some of the funds currently being spent by these entities can be used to maintain the new consolidated network. The logical entity to perform this function would be the State Department of Administration.

The overlay network will consist of high capacity trunk lines, medium capacity secondary lines, and feeder lines to interconnect regional networks.

4.2.1.2.2 Network Management Committee

The Network Management Committee would establish policy and receive input from representatives of all the user groups on the overlay system. The committee would establish and manage auxiliary functions such as:

- Network Maintenance and Troubleshooting
- User Database and User *Expertise Bank*
- Network Administration
- Traffic Priority
- Use of the Network for non-distance education functions (i.e. Lottery)

The Network Management Committee would logically be a function of the existing Educational Communications Board, which already has representatives from DOA, UW, VTAE, private colleges and DPI on its board.

It is envisioned that the overlay network will require a system integrator and a management group. ECB is the logical agency to provide the management and user assistance functions.

4.2.1.2.3 Network Manager

The network manager would be an administrator charged with carrying out the policy of the Board. This person would also chair the *Network Scheduling Committee*, which would allocate time on the network and resolve conflicts.

4.2.1.3 Access Considerations

In both the most urban and the most rural portions of the state, the topology of the overlay system must be designed to provide access to educational programs which is as equal as possible:

- For Instruction.
- For Staff Development.
- For Administrative Teleconferences.

There are two basic ways in which the connection from local and regional networks can be accomplished:

- Local Consortium pays all connection costs.
- All connection costs are accomplished via a fixed-fee arrangement (rural routes, where connection costs are higher, are partially subsidized by the urban consortia which benefit from a more extensive in-place network).

The decision to employ one or the other of these connection costing methods is best left to the network management.

4.2.1.4 Fees

One of the first jobs of the network management will be to determine the methodology used to assign costs. The following recommendations are pertinent:

- Costs on the main interconnect (Tier 1) network should be allocated strictly on usage, with a monthly connect fee assigned to all institutions and agencies which is as low as practical.
- Costs on the Tier 2 network should be managed in partnership with the Colleges, Universities, or other institutions which they feed. Circuits may be dedicated or switched, with assignment of lease costs on low-traffic routes made on a basis whereby future users will pay down on the original capital costs borne by the pioneering users.
- The network manager and the appropriate state personnel should maintain continuing liaison with the Public Service Commission in order to ensure continued cost effective pricing and predictable costs for future network expansion. If possible, formulas should be developed which use distributed costs, number of users and installed capacity as parameters resulting in expansion costs which are determinable in advance.

The network management must decide how to allocate the network access costs.

The overlay trunk line costs should be recovered based on usage; secondary line costs should be shared among users.

Continued efforts will be required to help reduce network costs

- Fees should be related as closely as possible to usage for the overlay network. For regional and local networks, it is common practice to divide the entire network transportation cost by the number of users, since *network connectivity* is being purchased rather than a local access loop. Nevertheless, even regional and local networks will probably be billing on a usage basis in the future when fiber to the curb is a reality.

4.2.2 Feature #2: Minimum Disruption Of Existing Networks/Procedures.

The establishment of the overlay network should be done in a manner which does not burden existing regional or local capacity, and which allows local procedures to remain the same to the largest possible extent. The "loop/star" topology proposed will accomplish these goals. All equipment purchased should have password protection at all levels so as to safeguard local programming.

4.2.3 Feature #3: Voice/Video/Data Capability

Based on the needs of all users, a statewide network must have integrated voice, video and data capability. Many of the wideband networks currently installed in Wisconsin have assumed that the most important element will be video. However, data carriage will be an equally important requirement as distance education network users become more familiar with the technology, and as more and more costs are accrued to provide high-speed data transmission. In fact, some college-level educators have stated that interactive data communications use in the classroom will eventually exceed the demand for video communications (for instance, high-speed audio graphics is rapidly becoming the technology of choice for many college/business teaching partnerships).

Although video gets the most "attention", voice and data capabilities are just as important for the network and its users.

A statewide network must therefore be capable of carrying voice telecommunications traffic for PBX interconnect, data traffic for computer traffic, and all five levels of video from HDTV to sub-DS1 teleconferences. It is very important to note that once full integration occurs, the video/data/voice datastream completely reduces to digital data traffic which maintains *no inherent differences* between the modes. To have a separate network for each mode would be equivalent to building a separate highway for trucks and another one for cars. Even institutions which do not anticipate any uses for full motion video should not short-sightedly limit their interconnects to lower-value increments such as primary rate ISDN, since it only requires 28 LAN connections to reach the DS-3 level.

Some existing distance education network users have indicated that they could realize substantial savings in their voice and data communications budgets by routing the traffic on the unused overhead bandwidth of the video channels used by their leased networks.[1] In some instances it is possible to completely offset the local costs of a video network based on the savings realized by carrying PBX voice and data over the same facility.

Ultimately, it is expected that all state uses of information technology would travel on the same highway and use compatible protocols, whether they be full motion video, compressed video, ISDN, or non- synchronous data traffic.

4.2.4 Feature #4: Establishment of Standards

The establishment of proper standards along with the development of the "expertise bank" required to implement them is critical to the success of the new network. For instance, it is imperative that all new network elements be SONET and CCS7 compatible as well as ATM[2] migratable in order to ensure connectivity and lowest possible cost.[3]

Recommended standards are fully discussed in Section 4.4.2 of this document.

4.2.5 Feature #5: Easy To Use/Transparent To Users

The importance of ease of use cannot be overstated. The overlay system must be an aid to education, not a hindrance. Most users do not care what kind of technology is used to satisfy their communications needs as long as it does its job without placing a burden on the person who operates it. The more difficult a system is to operate, the less likely it will be used at all.

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[1] This additional capacity must be obtained at an incremental cost in most cases if video transportation is being leased, which is one reason that this document recommends the use of "high-cap" DS-3s in the statewide network.

[2] ATM stands for Asynchronous Transfer Mode.

[3] The true utility of SONET and ATM may be appreciated with an analogy. Just as tractor trailers operated by interstate carriers are usually switched to local delivery vehicles only at the terminal yard, conventional fast moving data traffic can only be inserted at the endpoints of a fiber route (*POPs*). SONET adds a timing frame structure which makes it possible to add signals at mid-span, thereby saving the cost of an extensive tail circuit. For trucking companies, this system would be akin to door-to-door direct delivery through observance of a very rigid "just in time" inventory management system. New loads would be added and freight delivered directly to the user at a guaranteed time so that maximum efficiency is achieved. ATM takes this process one step further by allowing partial loads from different users to be combined.

One reason that centralized management and establishment of standards is necessary is to address the ease-of-use issue. Even under the best of circumstances, using a high-capability network is difficult.[1]

Another feature in the ease-of-use category is transparency. As indicated previously, a statewide network must also be capable of transmitting voice, video and data traffic over the same facility to easily addressable endpoints. Even though this feature requires fairly complex equipment and operational software, to the users of the network it should be a completely seamless function. From the user's perspective, it should be a "peer-to-peer" network, with each user or piece of terminal equipment addressable directly without changing networks, asking for protocol conversion, or specifying translation tables.

4.2.6 Feature #6: **Hybrid Dedicated/Switched**

Three basic network sub-systems have been identified in this report: the overlay network, regional networks and local networks. Each of these networks utilizes a variety of technologies to meet its specific needs. The first two network elements (overlay networks and regional networks) would ideally consist of predominantly digital systems. At the junction of each network sub-system, a node control point would be required to provide the proper interface.

In a digital network, digital routing switches would be required at the node control points to switch traffic between network elements. The design would be similar to current computer Local Area Networks (LANs) which use a backbone TDMA system to connect clusters of dissimilar LANs such as Token Ring, Ethernet and Appletalk. Traffic on any of the given LANs would stay on that network unless the data is addressed to a network resource device or another network. In this way the backbone system need only be engineered for the anticipated traffic that travels between networks. The network traffic manager would ensure that dedicated capability as purchased from the vendors is matched by switched utilization on the part of the local networks.

The statewide network would also require sufficient capacity to accommodate dedicated full time voice, video and data channels for special applications such as the TV and FM interconnect, and for other applications where single users would require common lease increments (such as DS-1s). These special applications would not be switched but would require that channels be dedicated on a point-to-point basis.

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[1] In spite of the fact that the Indiana IHETS system is one of the most user-friendly in the country, the trouble log indicates that very few wide-area telecourses proceed without a hitch. Most users of that system have volunteered the information that the complexity level is the maximum which would be tolerable.

4.2.7 Feature #7: Connectability To Local Systems

Another important feature of a statewide network is that it provides a flexible and inexpensive means for connecting to local network systems, as well as provide a predictable upgrade path. Since local networks will have a wider range of technology choices, the overlay network must utilize a common interface that will allow virtually any local network to access the state network. In some cases, codecs may have to be provided to interface with analog signals. Since the majority of the State Overlay Network and the regional network elements are likely to use digital fiber and microwave, the local use of analog microwave, analog cable TV and ITFS links will require flexible interface equipment which specifies different connection equipment to accept all of these modes.

In summary, many of the analog types of systems, which are being offered predominantly by cable companies and some LECs, would require an analog-to-digital interface at a node control point on the regional network.

The cost of these interfaces is not expected to be burdensome, however, since microwave equipment and codecs can always be moved to other locations in order to affect a "rotating migration". There is, however, one notable exception. The use of "scanned networks" at the local and regional level is generally not compatible with the envisioned statewide system. While connection to the statewide network would not affect local usage of a scanned system, adding additional remote scanned sites through the overlay network would be a nightmare from both a technological and a utilization standpoint. It is recommended that scanned systems look toward migration into non-scanned "quad split" or compressed video networks (requiring access to the codec).

There are several techniques which should be considered in making the system as reliable as possible.

4.2.8 Feature #8: Reliability/Redundancy/Route Diversity

Without question, operational reliability is one of the most important features that any network must provide.[1] Distance education networks are typically used to duplicate live classroom conditions for students in remote locations, or to eliminate the need for travel for staff development. Scheduling of instructors, students and facilities is difficult, and requires a good deal of effort. A network failure could cause classes to be severely disrupted or canceled. Consequently, rescheduling classes causes a great inconvenience for students and can be both expensive and time consuming for teachers and administrative staff. Similar concerns pertain to the video and voice traffic potentially to be carried by the network.

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[1] One of the regional consortiums contacted for the *Needs Assessment* operates a regional microwave system which, primarily because of maintenance factors, is patently unreliable. This has caused extensive friction between the sponsoring VTAE and its K-12 and business clients, to the point where new programming of any sort is suspect.

To achieve a high degree of network reliability, the statewide network must be designed with "hot stand by" system redundancy and route diversity features. System redundancy would require that critical network equipment be duplicated or backed up so that a single electronic equipment failure would not cause a complete failure of the network, and could be automatically compensated. Route diversity would require that network transmission facilities be built so that critical network links follow alternate routes to the same destination. In the case of a failure, route diversity would enable traffic to use the alternate route to reach the desired destination. The switching of channels to alternate routes must be automatic and transparent to users.

System redundancy and route diversity would be most prevalent in the overlay and regional network elements which would carry most of the inter-regional cluster traffic as well as statewide traffic. The most effective means available to implement route diversity in the Tier 1 overlay network would be to use a "ring and node" topology, which would allow the network to be back-fed during a cable cut. An additional benefit of this topology is that the capacity of the Tier 1 network would be substantially increased because of its bi-directionality. At the Tier 2 level, the star topology would require either alternate paths or alternate technologies to fully implement diversity.

At the local level, full redundancy and route diversity would be too costly to implement initially. Although this would impose an occasional hardship for the individual institution, it would be neither more severe nor as often as occasional "snow days". As more local networks become interconnected, some degree of redundancy and route diversity will be realized through local node switches.

4.2.9 Feature #9: Sufficient Bandwidth

As discussed in the technical standards section of this report, the state network must be capable of carrying multiple DS-3 (OC-3 under SONET) and DS-1 channels. Wideband Level 3 video channels will require a minimum of 36 Mbps of bandwidth in a 45 Mbps digital transmission system. Low bandwidth Level 5 teleconference-video channels would require use of the DS-1 circuits, which should be bundled into DS-3s and the overhead DS-1s wherever possible. Users should use standard H.261 codecs allowing them to select the amount of bandwidth they need for a given application in 64 Kbs increments. The amount of bandwidth available in these types of systems range from a low of 128 Kbps to 1.544 Mbps (DS-1) or greater.

Any lease arrangement must clearly specify the pricing method to be used for implementing additional capacity.

Sufficient capacity exists in the fiber systems being implemented by local and inter-exchange carriers to handle the anticipated network traffic requirements of a statewide distance education network. Difficulty is encountered when attempting to match future vendor capacity with anticipated growth in user demand. The capacity of light fiber doubles approximately every five years as the cost of terminal equipment decreases and the technology advances. Under the terms of most existing 10 year leases, the 400% cost-per-channel advantage devolves solely to the vendor, because the user must pay for the entire capital investment.

Since the leasing of *bandwidth* is being recommended, the network management would either be responsible for purchasing the codecs, or they could be included in the lease with the proviso that they would be accessible to the state. Codecs should be ultimately flexible, such as are the ABL codecs, so that the hardware and software can be upgraded as bandwidth requirements change (as opposed to scrapping the codecs and starting over). The recommended mechanism for assuring future expansion would be based upon one of the following scenarios:

- Pricing of additional bandwidth would be based upon a formula employing factors of switching equipment costs, percentage of capability used, and route-miles, among others. Either users or vendors would be able to precisely calculate costs as time goes on.
- The lease could be based upon a *percentage of fiber pair capacity*. As the capacity of the fiber increases, the user could take advantage of his share merely by upgrading codecs.

4.2.10 Feature #10: Network Security

Another important requirement with respect to statewide distance learning networks is that they provide security from unauthorized eavesdroppers. This is important because there will be many different users on the system at any given time, some of whom may be in competition with others for programming or students. The digital systems proposed for Tiers 1 and 2 of the statewide network should provide the necessary level of security to maintain program integrity, respect copyrights, and generally assure that video, data and voice messages are delivered only where they are sent. Digital signals are easily encrypted, difficult to decode by unauthorized persons. Password protection at the various network levels should ensure an adequate level of security.

In local networks, security could present a problem if analog AM or FM video equipment is used (such as is employed in many of the Cable TV systems). Scrambling of these signals is possible (such as video inversion, sync compression, or the use of negative or positive interference carriers), but is not secure from sophisticated tamperers. In some cases, higher cost scrambling and de-scrambling equipment (such as the Zenith system) may be required to keep unwanted viewers from receiving the channels. Security for voice and data channels in the last mile may require fully digital links which by-pass local Cable TV providers if messages are intercepted by unauthorized persons.

4.2.11 Feature #11: **Utilization of the Overlay System By Business Partners**

Once the overlay network is in place, expansion of the system to teaching hospitals and businesses offering vocational courses will certainly occur. With this expansion in mind, the overlay network should be configured and positioned to handle this traffic. The role and the usage limitations of the network by these entities must be determined with full cooperation and knowledge of the Public Service Commission, the LECs and the IXC carriers, so that the issue of using public money to bypass commercial carriers does not arise. It should be noted that although the commercial carriers would undoubtedly be used to form the bulk of the overlay network, the rate charged will be certainly lower than that offered to the business community at large (especially if a "most favored nation clause" is in effect; cost of time on the STS phone system is at least 40% less than equivalent time available to the general public).

This problem is not unlike the contractual language which is usually placed in government telephone leases which forbids resale to customers who are not a member of a defined set of users. It is entirely possible that the communications vendors and the PSC would require separate contracts for video transportation to non-state supported users. On one hand, this contract arrangement might not be objectionable if the network extensions were completely transparent to the user. However, there may be some well defined circumstances when some network services must be billed to end users, including business users. These circumstances should be well defined in advance to be certain that they do not violate PSC requirements for operating as an unregulated system integrator as opposed to a common carrier.

4.2.12 Feature #12: **Availability of Centralized Planning, Leasing, Administration, and Maintenance**

Certain network functions would logically be done by state personnel.

Many potential system users expressed the fear that a complex distance education system would be implemented without proper followup support.[1] At a minimum, the following services would be required in order to give comfort to the users:

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[1] Given the history of other statewide communication technology efforts, this fear may be justified. For instance, the statewide Emergency Medical System (EMS) repeater network was installed 10 years ago using grant money, but **no funds were allocated for system training and maintenance**. As a result, the system is so unreliable that ambulance technicians carry cellular phones rather than rely upon the repeater system.

- Technical expertise to solve local problems with codecs, monitors, and other video equipment.
- Maintenance staff to maintain the equipment on the state's side of the Demarc.
- Network management and administration to fine tune the network, determine when more capacity is needed, provide switched access and implement new software.
- A system integrator function to write performance specifications and acquire capacity from vendors.
- A program scheduling function.

It would be logical for a user committee to schedule programming, the WECB to manage the network and conduct maintenance, and for DOA/BITM to act as the system integrator.

4.3 Constructing the Network from Currently Available Resources

4.3.1 Fiber Optic Resources

Most of the fiber required for the state overlay system is already in place. However, the needed switching equipment is not.

As mentioned previously, the majority of the network will undoubtedly be composed of light fiber. During our evaluation of fiber facilities throughout the state, information was gathered on all known fiber optic distance education networks (both existing and planned). At the time of this report there are 22 such projects. All of the networks would be classified as regional. The proposed regional networks are located in all geographic areas of the state. A state map was developed showing the location and topology of each network within the state. This map was then overlaid with the known locations of vendor fiber and switch locations. The results of this evaluation showed that the great majority of the fiber needed to build most of the proposed networks was already in place. Further, most of the fiber routes required to interconnect the regional networks into a statewide network are also in place. It is the stated goal of the telephone industry to have all central offices in the state connected by fiber by the year 1995.

To complete the State Overlay Network connecting all of the major user groups, some additional fiber may have to be added to a few of the network segments. However, the presence of the fiber cable itself is only part of the story. Building the regional and overlay networks would require the addition of extensive network switching equipment and reconfiguration of existing fiber multiplexers along the proposed network routes. Except in a few of the major cities, most of this equipment would have to be purchased by the common carrier vendors and charged back to the state. If possible, multiplexing rates should employ 1 Gbs switching equipment.

An inventory of existing resources as it relates to regional and local networks has been developed as part of the distance education computer database deliverable of this study, and is available in electronic form.

4.3.2 Fiber Optic Issues

Digital fiber optic cable is clearly at the top of the migration ladder; however, it may not be cost effective for some time in most last mile applications. Early in the migration process other technologies such as analog cable, ITFS and point-to-point microwave will play a significant role. As the ultimate migration to digital fiber is being completed, the role played by cable TV, microwave and ITFS will gradually shift to more specialized applications such as reaching home-bound students and businesses who are not yet connected to fiber facilities.

For the next 7 to 10 years, technologies other than fiber will be cost effective for local systems.

On a national scale, last mile cable TV fiber systems using analog AM and FM technology seems to be gaining popularity among distance education planners. The primary incentive for selecting this technology has been the low cost and easy "loop through" installation of these systems. Many LEC vendors promote all digital fiber systems in the local network. Recent pricing information indicates that digital solutions are not presently price-competitive with analog cable TV systems for most rural and suburban applications at the present time; but the cross-over point is expected to occur approximately seven to ten years in the future. Analog local networks should be configured to be amortized over this time period.

Ultimately digital fiber will be the most compatible with other network elements and will provide a clear migration path to enhanced features such as SONET, frame relay and broadband ISDN. Digital microwave may be required in some forms up through the planning horizon, however, if only to transverse rough terrain and to provide portable capability.

4.3.3 Cable TV Resources

There are hundreds of Cable TV facilities operating throughout Wisconsin; nearly every community of more than 5,000 persons has a Cable TV system. Some of these cable systems already have an unused educational access channel. Many others are facing franchise renewal, during which a requirement for educational access could be obtained as a renewal sweetener.

The electronic database included as an addendum to this document contains a tabulation of Cable TV operators throughout Wisconsin.

4.3.4 Cable TV Issues

As discussed previously, the advantage that analog cable TV fiber systems offer over digital fiber is that they often provide many more channels for the same price as the one or two channels offered by digital fiber providers. This may be especially attractive to avoid putting excessive reliance on a "scanned" system.

Disadvantages include the maintenance, reliability and expandability issues as discussed in an earlier section. It should be remembered that HDTV video, when available, will be a digital technology, requiring digital transmission. Leases should contain a re-opener at the time digital technology is available at the curb in the local community; at the same time, the possibility that the Cable TV company itself may migrate to digital technology should not be overlooked.

Up to the present time, the WECB has not been successful in sustaining an ongoing dialogue with representatives of the cable industry. It is deemed extremely important by this consultant that a reliable liaison be established .

4.3.5 Satellite Resources

The two main uplinks employed are at the TOC in Madison and at Teleport in Skokie.

4.3.6 Satellite Issues

The satellite option reflects some rather unique considerations. A substantial role is expected for satellite technologies both during the migration process as a means of distributing one-way video programming, and after the statewide system is in place as a means of augmenting broadcast network capacity. In the future, DS-0 and two DS-0 data rates will be readily achievable with VSATs, while SCPC[1] two-way video may be cost effective in the near future for use as a low-volume peak leveler. The progress of General Instrument's GI-2000 "Entertainment Quality" 1/8th transponder leasing should be monitored; at $750,000 per year for four video channels, it could be quite cost effective for multichannel one-way programming.

4.3.7 Microwave Resources

Microwave resources are available within the state as supplied by common carriers (such as MRC), as utilized by several regional networks (such as

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[1] SCPC stands for "Single Channel per Carrier."

Chippewa Valley Technical College and Trempealeau Valley Communications Co-op - see Appendix C), and as the existing DOT microwave interconnect system (see Appendix E-1).

4.3.8 Microwave Issues

Although analog microwave can be cost effective for use in the local loop, it is not recommended as a migration path for the regional or overlay network. For reasons of compatibility, only digital microwave should be considered for use in these network components, and then only if light fiber is not cost effective.

As part of this study, the Wisconsin Department of Transportation was approached to determine the conditions under which their microwave system could be utilized as a base from which to migrate the overlay network to light fiber. The main concern, received from the Department of State Patrol Bureau of Communications (DSP-BOC), was that sufficient personnel would not be available to monitor such extra-agency usage. Assuming that appropriate personnel could be found, there is wonderful synergy in employing the DOT microwave system for at least a portion of the overlay network capacity because:

- Due to the relationships of the frequencies which would be employed, the existing towers, antennas, and waveguides could be used, thereby saving a great deal of money.
- The DSP repeater sites already employ emergency power, secure housing, and route redundancy.
- A remote monitoring system is in place.
- A maintenance staff is in place.
- The microwave system offers an alternative for some high-cost fiber routes at least for the near term (approximately four two-way channels could be coordinated on the backbone).

The Wisconsin Department of Transportations's microwave system could be a valuable resource in creation of the overlay network.

The migration issues raised by using point-to-point microwave for overlay network components will be fully explored in Chapter 6 of this document. In addition, incorporation of the existing TV and FM network into the system will be investigated.

4.3.9 ITFS Resources

There are numerous consortiums successfully utilizing ITFS as a distance education medium throughout Wisconsin, including systems in Milwaukee, Green Bay, Chilton and Madison. Many of these systems employ an audio return path. Several systems are due for expansion within the next two or three years.

4.3.10 ITFS Issues

ITFS is an AM microwave technology and therefore has a somewhat higher signal-to-noise ratio than does FM microwave or light fiber. ITFS is not well suited to carrying digital data services, and alternate paths should be selected if such capability is desired. When interfacing with light fiber, every effort should be made to ensure that the signal-to-noise ratio at the pickup point is as high as possible in order to avoid digital picture "blanking".

4.4 Summary of Recommended Standards

This section summarizes the suggested contract terms that users strive for when entering into contracts with vendors. More detailed contract terms and technical standards may be found in Appendix R.

The following section outlines the standards which should be considered when obtaining the above technology resources. These standards fall into two classifications:

- Recommended standards for the state's overlay network.
- Recommended standards for the local and regional networks.

This section highlights some of the important items addressed by the full *Standards Document* which is included as Appendix R. Standards are ever evolving and changing; as such the standards presented herein should be viewed as a snapshot in time. One of the recommended tasks of the WECB will be to maintain the currency of the standards document.

4.4.1 Summary of Recommended Contract Terms

The fact that telecommunications technology is rapidly changing should be viewed by the state as both an opportunity and a concern. Rapid advances in compression techniques and the availability of digital fiber optic cable facilities make statewide two-way interactive digital video systems a very viable option today. However, rapid advancement in technology also promotes obsolescence. Since 1960, the key characteristics of telecommunications computer hardware such as cost, reliability and density have been improving at the rate of at least 20% per year. To put this in perspective, hardware capabilities costing $100 in 1960 would have cost $10.74 in 1970, $1.15 in 1980, and $0.12 in 1990. Based on this history, there is no reason to believe that the rate of change is decreasing. Many experts, in fact, believe the rate of improvement today is closer to 40% to 70% per year in some areas.[1]

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[1] Alter, Steven, "Management Information Systems, a Management Perspective." (Reading, Massachusetts: Addison-Wesley Publishing Company, 1992, p.27).

The Ernst and Young Report of 1990 recommended the use of satellite technology for the State Overlay Network, as did the NCTC study before that. Two years later we find that fiber is not only strategically in place around the state, but is economically competitive with satellite technology for many uses. Therefore, it is conceivable that video technology bought today will be less costly in the future or even made obsolete by further advances in technology. This inevitability is a strong warning that the state and local consortiums must move cautiously when entering into long-term network contracts with vendors. Contracts must be written to contain as much flexibility and protection as possible in order to compensate for the inevitable technology advancements and facility cost reductions. At the same time, those network components which are to be contracted by the local end users should be reviewed for compliance with the pertinent terms and parameters.

This does not mean that either the state or the local consortiums should wait excessive periods of time until wide-band communications becomes less expensive. The availability of interactive video, data and voice networks at nearly any cost represents a paradigm shift of monumental proportions, which ultimately will change nearly every aspect of our society. With proper precautions, acting in the short term will allow the staff support structure to be put in place so that individual institutions, consortiums and the state can "hit the ground running" with a mature product when ubiquitous interactive television and multigraphics becomes the educational norm.[1]

In the opinion of this consultant, many leases being signed by educational consortiums at the present time contain some disadvantageous clauses from the standpoint of the user. This consultant recommends that the following issues be considered when entering into interactive video network contracts with vendors (these issues apply to all three network components, and both the state and local users):

1) The network delivery system topology should be designed by a consulting engineer representing the lessee. This consultant should also maintain a liaison with the state-level system integrator in order to ensure standards compliance, and should supervise construction as well as conduct contractor evaluations, negotiations, and proofs of performance.

2) Lease periods should be as short as are financially viable. The current ten year contract term requested by some distance education vendors may be an excessively long period to be committed to a single technology. Seven years, with a three year option to renew, should be the maximum contract commitment. This time period is sufficient for the vendor to recover his capital costs. Possible income from the distance education system should be considered on the positive side of the ledger, as should the cost of personnel to manage the operation of the network on the negative side. If periods longer than seven years are required for economic reasons, the following special provisions should be included in the lease:

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[1] One way to look at this is that a tool which is most frequently used is the least expensive on a per-use basis, but to use it properly requires a substantial investment in learning time. In the 1960s, it was not unusual for an engineering student to spend over 100 pre-inflation dollars on a good slide rule. Through at least 20 years, this calculates to approximately $0.0015 per use.

- The contract should contain re-opener language triggered when certain technical milestones are reached, or should contain a contract "buy-out" provision. Also, the lessee may agree to a longer lease in return for other concessions, such as a lower cost on additional bandwidth in the future. For example, the vendor should agree to provide "not to exceed" prices for each year of the contract for additional DS-1 and video channels. Another important example is that the lessee *must* have the right to multiplex additional video or computer data signals on existing channels without incurring an additional cost obligation, as long as no incremental maintenance burden is placed on the vendor.[1] (Credit Course) and below, while 4-channel multiplexing can be used for Level 4 video (Non-credit courses).
- The lessee should have the right to specify the dedicated terminal equipment to be used, such as codecs, multiplexers, switches and network software.[2] At the end of the lease term, such terminal equipment should belong to the lessee at a known buy-out cost. At the option of the lessee, the lessor should continue to maintain the equipment at a known cost on a year-to-year basis, should permit the installation of the lessee's own equipment (subject to approval of all parties), or should allow newer terminal equipment to be installed while the older equipment is moved to new network links.
- During the life of the lease, it should be the right of the lessee to specify upgrades to existing dedicated terminal equipment as well as the additions of optional equipment, enhancements and/or increases in capacity at prices which reflect the cost of the equipment installed plus a

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[1] As a practical matter, consortiums leasing DS-3 capability should investigate frame multiplexing *first* when additional capacity is required. This technique is especially effective for backbone transportation, and allows two to four video signals to be carried over one DS-3. At the present time, this equipment is not available from the common carriers, which prefer to provide additional DS-3s to increase capacity. Although some loss of resolution occurs with this type of multiplexing, there is no loss of motion capability as there is with compressed video. Two-channel multiplexing is a reasonable compromise for Level 3 video

[2] This refers only to equipment which is not shared with non-related users. The carrier must pay for upgrading multiplexers and switches as required to establish the connections to their infrastructure.

reasonable override cost for installation and maintenance.[1] Software updates of the "fractional release" variety (such as xx.10 to xx.20) should be performed by the contractor as a matter of maintenance, as should all "bug fixes". The existence of major software releases (such as 1.xx to 2.xx) should be made known to the lessee, and should be installed at cost plus a reasonable override.

- The entire cost of the network should not be paid to the contractor in advance.[2] Bonding authority, if used, should be employed as a means of self-financing a timed payout schedule. A pricing formula should also be included so that it is known in advance approximately how much additional capacity will cost once the contract is in force.
- With the exception of "hard" costs associated with dedicated terminal equipment, all distance education contracts specifying bandwidth or service transportation should contain escape clauses and waivers to provide adequate flexibility to cover technology obsolescence. For example, a "most favored nation" clause states that for a certain period of time after signing the contract, the lowest price is guaranteed. This means that if the network manager discovers that the same type of integrated network service has been purchased from the same vendor for less money elsewhere (under the same conditions), the vendor will refund the difference. This technique assures that the contracting agency has received the least expensive contract price. It is true that defining "sameness" can be tricky; therefore a proper formula based upon miles, system capacity, and other pertinent factors should be agreed upon prior to contract signing.[3]
- In all cases, lease terms should make it clear that bandwidth is being leased, not transportation services.[4] Whatever bandwidth increment is being leased (DS-1, DS-3, 20 MHz) should be the exclusive property of the lessee during the lease term; no additional cost can be assessed for additional uses of the increment which fit within the designated bandwidth other than for required terminal equipment. For instance, a DS-3 (45 Mbs) lease initially used for 36 Mbs

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[1] *Access Wisconsin* currently uses a model called *LRIC* to perform this function.

[2] It should be acknowledged that the *NWECS* consortium was able to save money by having the schools borrow money at a rate the telcos could not match. In a go/no go fiscal situation, prepayment may well be the most attractive option even though it may not be ideal from a strategy standpoint.

[3] Undoubtedly the easiest way to establish a "most favored nation" environment is through the centralized leasing process described subsequently in this document. Until a mechanism is established to administer centralized leasing, however, the lease should contain either provisions for buy-out or for assumability at the most reasonable cost possible. In order that such assumption is possible, the contract should be reviewed by the state distance education *clearinghouse* which this study recommends be chaired by the WECB.

[4] This is expected to be a somewhat sticky issue, especially with respect to the independent telephone companies which are not in the habit of providing this type of service. In reality, the concept of "user" bandwidth versus that which belongs to the carrier is somewhat murky. The important concept, however, is that the lessee maintains the right to use the full 45 Mbs of a DS-3 in whatever manner he or she chooses (including adding multiplexed signals), and at any point in time (subject to carrier equipment restrictions). This means none of the DS-3 capability will be re-sold to anyone else by either party.

video could not specify additional transportation costs for "overhead" DS-1s or DS-0s used for data or telephone circuits.

- There should be a specified cost for additional lease increments during the lease period. For instance, if a DS-3 is being leased, the maximum cost for additional DS-3s should be specified for each year of the lease term. If the standard price is lower when the milestone is reached, the lessee would receive the lower cost.
- An engineering study should be conducted to determine whether switches, terminal equipment and software utilized by other nearby entities and consortia can be utilized to reduce the cost of the leased network. The assistance of the carrier would be valuable in this determination, as would input from the WECB. The WECB network manager should make every effort to secure network facilities that will provide user control of bandwidth at the lowest possible aggregate cost. An arrangement of this type will eliminate charges for the network during periods when it is not being used. Other area consortia should be contacted to help determine whether WECB's requests can be integrated with those of other entities to provide a lower cost.
- Assuming that a suitable agreement can be worked out with the appropriate regulatory agencies, subsequent users who employ fiber routes initially installed by individual consortiums for distance education purposes will reimburse the consortium for a proportionate share of the capital costs for last mile fiber (pioneer's consideration). Alternatively, the pioneer's preference could be given at the front end based upon the vendor's estimate of future demand on the newly constructed circuit. Conceivably, investor-owned carriers could also find a role for the company's investors so as to further reduce the cost of new fiber without substantially increasing the rate base. A "most favored nation" clause, if obtainable, would allow fiber lease rates to decrease over time as lower rates are established in the relevant service area.
- The contract should describe the approximate pricing mechanism to be used for adding and deleting sites and channels. It is important to note that an evolving network may be able to add new endpoints in several different ways (from more than one switch). The least expensive option should be employed, consistent with required flexibility. This pricing mechanism will aid the network manager in providing projected costs associated with grooming the network without excessively involving the carrier.
- Codecs and multiplexing equipment, whether leased or purchased for use on the user premises, should be flexible enough to upgrade to Asynchronous Transfer Mode (ATM)[1], SONET, wider bandwidths, and dynamically allocated video/data/audio applications. Users should have password access to the codecs and dedicated switches both physically and through monitoring software.

A detailed discussion of lease terms are included in Appendix R, attached.

Ideally, the state could act as a centralized leasing facility to both lower the cost of all leases and to obtain the most favorable terms.

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[1] ATM is the engine which will make access on demand and bandwidth on demand a reality (video dial tone)

3) Assuming that a suitable agreement can be worked out with the PSC, subsequent users who employ fiber routes initially installed by the state or by consortiums for distance education purposes will reimburse the state or the consortium for a proportionate share of the capital costs (pioneer's consideration). Alternatively, a pioneer's preference could be given at the front end based upon the vendor's estimate of future demand on the newcircuit. Conceivably, investor-owned carriers could also find a role for the company's investors so as to further reduce the cost of new fiber without substantially increasing the rate base.

4) The state network manager should make every effort to act as a time broker and secure network facilities that will provide user control of bandwidth at the lowest possible aggregate cost. An arrangement of this type will eliminate charges for the overlay network during periods when it is not being used.

5) All distance education contracts should contain escape clauses and waivers to provide adequate flexibility to cover technology obsolescence. For example, a "most favored nation" clause states that for a certain period of time after signing the contract, the lowest price is guaranteed. This means that if the network manager discovers that the same type of integrated network service has been purchased from the same vendor for less money elsewhere, the vendor will refund the difference. This technique assures that the contracting agency has received the least expensive contract price. It is true that defining "sameness" can be tricky; therefore a proper formula based upon miles, system capacity, and other pertinent factors should be agreed upon prior to contract signing.

6) Wherever possible, the contract should contain terms agreeing to maintain stated levels of service for the life of the contract. For example, the state network manager may agree to maintain four DS-3 facilities on the statewide backbone for the life of the contract. The state, at its option, should then have the right to continually groom the network (employ the proper mix of service slots within the DS-3) and incorporate less expensive facilities into vendor's switches in addition to the contracted minimum if they are available from other sources at more favorable rates.

7) The contract should describe the pricing mechanism to be used for adding and deleting sites and channels. It is important to note that an evolving network could add new endpoints in several different ways (from more than one switch). The least expensive option should be employed, consistent with required flexibility.

8) At the present time, full DS-3 (*high-cap*) capability is only offered by some vendors at full tariff rates. FCC tariffs also may apply for some uses. The vendors must be encouraged, in the strongest possible terms, to apply to the PSC and the FCC for educational discounts on these circuits.

9) Codecs, whether leased or purchased for use on the user premises, should be flexible enough to upgrade to SONET, wider bandwidths, and alternate video/data/audio allocations. Users should have access to the codecs both physically and through monitoring software.

4.4.2 Technical Standards

This section contains detailed technical specifications for all layers of the proposed network.

4.4.2.1 General Standards

The standards recommended for the distance education overlay network, as well as the local and regional networks, are driven by the basic requirements underscored by the *Needs Assessment*. Since this study centers on two-way interactive video technology, it is appropriate that standards be selected for each of the five video resolution levels detailed under *Technical and Financial Implications* at the beginning of this chapter, as appropriate to fulfill the needs of the various categories of network users.

Recommended technical standards and example equipment is given in Appendix R of this document. In summary, these standards are compliant with protocols established by PBS, EIA, CCITT, NPR, FCC, and other regulating agencies and industry associations.

In the needs analysis, it was apparent that most respondents indicated a requirement for broadcast or near-broadcast quality full-motion video for use in credit courses. Some potential users also indicated the desire for two-way video systems featuring less bandwidth requirements such as T1 and fractional T1. T1 was also frequently mentioned as a requirement for data transmission in conjunction with or in tandem with video distance education systems.

For HDTV video transmission a 2-DS-3 solution is recommended (Level 1). Standards would include provisional FCC compatible signals employing a binary coded analog luminance and chrominance channel and a fully digital detail channel.

For the TV network interconnect this consultant recommends that Level 2 video signals delivered to or received by all sites meet the EIA, NTSC and FCC standards for video quality. Further, the user should adhere to the EIA RS250C specifications for local video production. At the present state of codec development, a full 45 Mbs will be required for digital delivery, although improvements within the next two years are expected to reduce the requirement to 22.5 Mbs. The determination as to whether the short, medium or long haul EIA specifications are used depends upon whether the local, regional or overlay network element is being considered.

For credit course video transmission, it is recommended that Level 3 video signals which are delivered to or received by a user site meet all pertinent NTSC standards for video quality consistent with today's 36 or 34 Mbs codecs. Within the next two years, 1/4 DS-3 is expected to support this level of resolution.

For non-credit course video, the resolution available in Level 3 may be decreased by half, for instance by employing alternate-frame multiplexing (Level 4 signals). This would allow the carriage of *two* programs in the same bandwidth utilized by one credit course.

For teleconferences, a minimum rate of 256 Kbs is recommended as Level 5, with a DS-1 maximum. The codec should be able to select the rate which is appropriate to the particular application. Audiographics applications should use ISDN primary rate within a DS-1.

4.4.2.2 Standards for the Overlay Network

4.4.2.2.1 General Discussion

The overlay network, as previously described, would serve to interconnect multiple clusters of independent regional networks with a reliable high capacity backbone. The overlay network would be capable of interconnecting all of the major educational user groups identified in the study, as well as state agencies and major businesses, with wide-band video, data and voice facilities.

The overlay network would require equipment and software facilities that could safely, economically and quickly transport multiple video and data channels over long distances. Use of the network should be seamless to the user, whether the electronic information travels primarily on the light fiber route or utilizes a microwave by-pass.

The envisioned evolution of the overlay network suggests that initially a mix of technologies will be employed. Systems already in place such as the DOT microwave links could serve as interim elements in the network until the fiber network is fully deployed. Similarly, satellite distribution could be used for the TV and FM interconnect for a few years if similar terrestrial capacity cannot be obtained in the interim.[1]

4.4.2.2.2 SONET Capability and Digital Services

Whether fiber or microwave is used for the terrestrial connection, all technologies must provide a clear migration path to SONET and Broadband ISDN services. This dictates that the overlay network be a fully digital network, and that the terminal equipment be maximally flexible (proprietary equipment and software are to be avoided). According to the current SONET specifications, the network must ultimately provide for digital switching and routing of high bandwidth (OC-nn) as well as low bandwidth (DS-1) channels.[1]

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[1] Telstar 401 would make available one Level 2 video channel, two Level 4 video channels and three audio channels for a lease cost which is 50% higher than the present interconnect payment.

4.4.2.2.3 Terminal Equipment

Many of the higher educational institutions in the state would like to have control of the codec and multiplexing equipment at their Tier 3 locations to enable them to dynamically select the amount of bandwidth needed for a given application. These potential users envision a network connection that is not locked in to only one bandwidth choice or a particular mix of DS-3s, DS-1s and DS-0s.

To meet the requirements of these users, the terminal equipment must eventually have dynamic bandwidth allocation capability and remote control software to enable users to select the bandwidth they need, when they need it, for any voice, video or data connection. SONET and evolving wide area signalling standards will enable this capability while allowing remote access and incremental billing. However, it is estimated by the carriers that full SONET and CCS7[2] will not be universally available throughout Wisconsin for at least 10 years. Demand, however, could accelerate the implementation of these services.

At the same time that the overlay network is moving toward dynamic allocation, the wishes of "minimum involvement" users must be respected. This means that institutions which do not have the inclination or the expertise to manage their own bandwidth should have it done for them by the overlay network manager.

4.4.2.2.4 Codec Standards

During the migration phase, before full system-wide dynamic allocation is available, users will allocate their T1 and fractional T1 teleconferencing and data transportation systems by properly addressing their DS-1 Channel Service Units (CSUs). Codecs which utilize the H.261 (Px64) CCITT video codec standards will interface properly to the envisioned system. Some of the higher-end systems now available which conform to these standards do have a degree of dynamic bandwidth allocation control; however, the maximum speed is generally limited to 1.433 Mbps.

For applications requiring higher bandwidth, the concentration of circuits into DS-3s and higher bandwidth increments would initially be done manually by the network manager based upon traffic history. This off-line method would eventually be replace by full remote control as compatible equipment is installed by both the overlay network management and the carriers.

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[1] Presently, central office switches such as the Northern Telcom DMS-100 are geared to switching DS-1 circuits and DS-1 Digital Cross-Connects (DXCs). This capacity represents a bottleneck in the distribution chain, since the transportation fiber and the multiplexing equipment is designed to concentrate much higher bandwidth increments. Presently, video switching capability is "appended" by controlling a "video switch" such as a Grass Valley VS-3 from the central DS-1 switch. When new systems are installed, wide-band DXCs which can directly switch DS-3 level bandwidths should be employed as soon as they are economically available; ultimately the central office switches should similarly be replaced.

[2] CCS7 may be supplanted by CCS8 in the near future.

Given the need for both configurable high bandwidth and dynamically allocatable low bandwidth, the initial overlay network must support both DS-3 and DS-1 transmission standards. The video quality required would follow the resolution levels tabulated earlier in this document, while improvements in compression software will allow the broadcast quality standards (NTSC & RS250C) to be realized on lower bandwidth segments. At that time, H.261 compressed video as well as DS-1 computer data could share DS-3 transmission facilities with broadcast signals by riding "piggy back". At that time, users should be employing fully configurable card-pluggable codecs in order to obtain the maximum degree of flexibility.

Theoretically, any standard DS-3 video codec can be used to digitize the video signal. When full compatibility is realized, the codec used in the overlay network does not have to be the same as the codec used at the local user end. However, since there are still some elements of incompatibility across manufacturers, all initially purchased codecs should be of the same manufacturer until such time as a codec "shoot-out" reveals complete functionality is preserved across brands. Currently most DS-3 video codecs are proprietary to a specific vendor and are incompatible with codecs made by other vendors.

4.4.2.3 Regional Networks

Regional networks generally consist of primary sites such as colleges, universities, VTAEs, CESAs, district high schools and state agencies. These primary sites would serve as node control end points which would be the point of interface for connecting the overlay network to nearby local networks. Conversely, local networks would have to connect to the regional networks through simple switching centers to gain access to the State Overlay Network.

Initially, regional networks will utilize a combination of fiber optics and analog microwave technology. Over the next 10 years, fiber systems will slowly replace analog microwave for most of these network applications, with digital microwave employed for difficult routes.

The same standards that apply to the overlay networks also apply to the regional networks. These networks must be capable of carrying both DS-1 and DS-3 signals, and should be positioned to migrate from manual allocation to automatic allocation using SONET and other standards.

Regional networks should resist using scanned networks; employment of other multiplexing technologies such as quad splits or even some microwave would be preferable for migration purposes. All video switches installed should be capable of easy expansion and full remote control using a computer.

4.4.2.4 Local Networks

The final network element is the local network. This portion of the network can best be defined as micro-clusters or sub-clusters in each regional network. An example of a simple local network would be a distance education system installed in a single community where there are several elementary schools; each of the schools may be interconnected via analog fiber, microwave or ITFS. An occasional link may be present to other networks in the area.

The on-campus distribution systems of VTAEs and colleges also represent local networks. Each local network within a VTAE district or community may be somewhat different than the networks designed to serve groups of high schools or independent colleges. In fact, the local networks are expected to represent the greatest divergence from common topologies and standards because the funds are minimum and the choices are maximum. For this reason, an additional burden must be placed upon regional network interfaces in order to avoid discouraging membership in the overlay club.

Some standards are pertinent, however, in order to ensure that interconnection is not inordinately difficult. These are:

- Levels 1 to 3 video should meet RS-250C standards.
- Multiplexed Level 4 video should meet industry standards for industrial applications.
- Scanned systems should be avoided or should be confined to the migration phase.
- All FCC standards for signal quality should be observed for the technology in use.
- NAB standards of good engineering practice should be observed (for instance, ITFS signals should exhibit less than 2 IRE of noise).
- Data circuits should be "clean" and exhibit no frequent re-transmissions. Circuit cross-talk and other spurious signals should be minimal for both radio-based and cable based systems.

Alone among the network elements, the local networks are deemed amenable to utilization of analog technology during the initial migration period to a fully digital statewide network. Frequently, the last mile component of a digital network is the most costly; at the same time, analog solutions are frequently plentiful, as cable TV systems and analog light fiber networks. Provided that the equipment investment can be recouped during the period of use, an analog local network can frequently be the only way to establish a distance education system at a reasonable cost. The following example cost comparison is instructive:

For a 3-channel network in rural Wisconsin (10 sites, 100 miles of fiber):[1]

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[1] GTE has conducted a study which contradicts the figures given below. However, it should be remembered that analog signals take up a larger fraction of the fiber capacity, a fact which increases the costs when using regulated carriers, but which can reduce the cost using Cable TV companies.

- **Digital:** Up-front installation costs plus 10 year lease costs: $2,660,000 ($241/mile/month)
- **Analog:** Up-front installation costs plus 10 year lease costs: $1,008,000 ($75/mile/month)

Interim solutions/standards should be implemented with the knowledge that they will be supplanted with SONET and digital compatible technology within 10 to 15 years.

4.4.2.5 Performance Specifications Summary

The following minimum set of audio, data and video performance standards should be employed throughout the proposed statewide network:

- All equipment should meet CCITT, EIA, FCC, NAB and other commonly accepted video and audio standards for the video resolution level desired.
- Equipment should meet EIA RS-250C long haul standards for Levels 1 and 2 NTSC video carried on the overlay network.
- Single mode fiber system performance is required for overlay network Tiers 1 and 2.
    - Laser launch equipment should be employed exclusively for Tiers 1 and 2 to reduce dispersion.
    - As soon as all-light amplifying equipment is economically available, it should be scheduled into the migration plan to replace electronic amplifiers.
    - All fiber links should have a sufficient loss budget to withstand the numerous splices expected through the years. (A loss budget of 8 dB plus 0.1 dB per kilometer between amplifiers is recommended).
- Analog multimode fiber systems should eventually migrate from a "loop through" topology to a "star" configuration.
    - Only high stability transceivers should be employed; if LED launching is used in the last mile, dual conversion should be employed.
    - Differential gain and phase should be less than 2% to reduce color smearing.
- For microwave links, only high reliability FM microwave should be used for Tiers 1 and 2.
    - Wideband (at least 25000F9) digital microwave bandwidths should be employed for each channel in order to enable DS-3 signals plus overhead T-1 channels.
    - 99.9999% reliability is required; route diversity is ultimately preferred.

- Equipment should be configured with hot-stand-by and UPS power if possible.
- Transmitter and Receiver equipment should be high-quality heterodyne units.
- For Local and Regional Network links and Overlay Tier 3.
- AM microwave such as CARS band can be used provided that 99.995% reliability can be achieved.
- ITFS transportation can be used for video as long as less than 2 IRE of noise is obtained.
- Data circuits should achieve 1 X 10 -10 BER.

4.4.3 Statewide Network Issues and Dependencies

4.4.3.1 Issues Relating to Selection of a Vendor

There are disadvantages to having one vendor design the network.

Wisconsin is fortunate in that it is home for numerous consultants and service providers specializing in distance education. These companies supply expertise and connectivity with respect to video, data and voice circuits via light fiber, microwave and coaxial cable in both a state-regulated and an unregulated environment.

In reviewing the extent of regional video networks in place in Wisconsin, however, several cases have been identified where the systems have actually been designed by the vendors who installed them. Several issues are raised by this type of inherent conflict of interest:

- The systems are generally designed around the capabilities and shortcomings of one technology or the equipment and cable routes available to one provider.
- An effective RFP process cannot be pursued because the specifications usually are not written to allow substitution of a competitor's products. An effective technology *mix*, therefore, cannot be pursued. Occasionally, less desirable technologies (such as scanning) are employed in order to reduce the system cost as provided by a single vendor, whereas a more effective technology mix involving other vendors could achieve the same cost objective without sacrificing functionality.
- There is no engineering advocate representing the user who can approve of system design and help establish standards for future connectivity and expandability.
- There is no system integrator who can achieve lower prices by consolidating requests by various institutions and agencies, while effectively dealing with state agencies.

A procedure for local and regional consortia to follow when acquiring distance education services is suggested.

In the view of this consultant, it is critical to the future health of the statewide distance education effort that the following procedure be followed by local school districts and regional consortiums when acquiring distance education services:

1) Have a qualified independent consultant conduct the following studies:
   - Needs Assessment
   - Feasibility Study
   - Technology Mix Recommendation
   - Cost Estimate
   - Establish Standards which are compatible with the state overlay network
   - Write the technical section of the RFP
   - Supervise the construction of the system
   - Conduct final proof-of-performance

2) Utilize resources and expertise available from the State of Wisconsin:
   - WECB
   - DOA/BITM
   - DPI

3) Investigate all sources of funding:
   - Wisconsin
   - REA and other National agencies
   - Private, such as Kellogg

4) Actively investigate joining a consortium with others:
   - Public
   - Private
   - Business Partners

It is expected that the cost for these engineering services should be in the $7,000 to $15,000 range depending upon local requirements and expertise level.

In opposition to the opinions expressed in this section, it is the opinion of some vendors, notably *Access Wisconsin*, that a vendor/user **partnership** can be just as effective as a vendor/user/consultant relationship.

4.4.3.2 Issues Relating to Local Administration

In order to prepare personnel and equipment to join the overlay network, there are several considerations which should be placed into the local strategic planning process:

There are several concerns which should be addressed by local network administrators when planning a network.

- Local PBX, wiring and other telephone equipment should be made compatible with digital and ISDN standards *to the desktop*.
- An extensive effort should be undertaken to obtain the consensus of all local institutions and businesses in order to determine participation levels and to address concerns. Business and hospital partnerships should be actively sought.
- The expertise level of local maintenance staff should be increased through correspondence courses or University Extension classes. Larger institutions should consider hiring a distance education technician. All technicians should be fully informed as to the signal qualities and reliability figures expected by the overlay network.
- All institution staff should be kept fully informed as to their responsibilities with respect to the new network. This refers primarily to the *Demarc* where state responsibility ends and local responsibility begins (for example, proper operation of local VCR and codec equipment is the responsibility of the local institution). The staff should also be made aware of assistance and expertise which is available at the state level.
- It should be perfectly clear that the local networks are responsible for the costs involved for local terminal equipment, classroom equipment, and tail circuits for overlay network connection.[1]
- Local networks should maintain constant communications with the local cable companies and the local exchange carriers to determine the availability of alternate technologies such as analog fiber, digital fiber, and CARS band microwave. At franchise renewal, concessions should be sought to provide two-way educational access at low cost, and system reliability concerns should be addressed along with outage restoral priorities.
- Originating institutions should be realistic in determining the resolution level of video required, as well as the number of channels. If local production is contemplated, they should realize that the TV networks have thousands of employees to program only one channel; those who are not familiar with the work level involved in production should contact other institutions who have an on-going program. Pertinent system managers should attend the state-sponsored "codec shoot-out" so as to personally view the various video resolution levels.
- When utilizing tower-based technologies, local network managers should be sure to factor in zoning hearings early in the design process, since these

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[1] One of the possible options being explored for state management of the overlay network is to bury the cost of tail circuits in a usage charge.

can frequently be substantial stumbling blocks. Consider contacting the WECB for advice on these matters.

- Attention should be given to the matter of programming and data security in order to protect copyrights and prevent unauthorized access.
- If already under contract to a vendor, local networks should negotiate future costs for increased capacity employing well defined factors.
- Care should be taken to ensure that classroom studio equipment and layouts are of sufficient quality so as to take full advantage of the available transmission bandwidth.

4.4.3.3 Issues Relating to Regional Administration

There are also concerns which should be addressed by regional network administrators .

- To the extent possible, regional networks should purchase bandwidth and perform an amount of manual usage allocation consistent with effective use of facilities.
- Regional managers should be aware of ITFS issues if the technology is employed in the regional network. A 10 to 12 year phase-out is anticipated. New source links should be sought for ITFS systems which receive programming off of the air or from other ITFS systems. In the meantime, regional managers should be wary of commercial ITFS interests which could reduce their capacity or limit the options of other nearby institutions (see the MMDS/ITFS pamphlet prepared by the WECB).
- When traffic on a fiber-based installed network begins to reach approximately 75% of the regional network capacity, regional networks should consider working with the State Overlay Network management to change dedicated circuits to switched circuits which will lower local costs while making additional trunking capacity available to other users.
- Scheduling responsibility should be assigned to a district person who can effectively represent your consortium or region at overlay network scheduling committee meetings. Make sure everyone knows of the availability of overlay network resources, such as the WECB Technical Operations Center, uplinks, and similar facilities.
- It is imperative that regional network managers work with the state network manager in the purchase of Fiber Optic Terminals (FOTs), multiplexers, video switches and codecs in order to ensure compatibility. Maintenance responsibility on each side of the Overlay/Regional Demarc should be rigidly defined.

- In general, all regional and local networks should motivate their staff and administration to make a major commitment to distance education technology throughout the "window of opportunity" which will exist between 1993 to 1997.[1]

4.4.3.4 Issues Relating to Overlay Network Administration

Overlay issues include staffing conserns, liasion with the PSC, and implementation of pilot projects.

- The overlay network management should establish a governing structure which provides the maximum input from the users. An effective working relationship should be established with DOA/BITM or whatever entity becomes the system integrator.
- The problem of additional staff required by DOT and DOA should be addressed by "renting" persons from other agencies, perhaps the DNR or the WECB.
- A continuing relationship must be established with the Public Service Commission. Attendance at hearings involving questions of "pioneering preferences" should be mandatory. The question concerning whether or not the Overlay Network Manager is a reseller of capacity under PSC regulations should be dealt with early in the process.
- The state should encourage maximum participation in the overlay distance education network by state agencies, educational institutions, and businesses.
- The overlay network management should conduct several *Pilot Projects* in conjunction with the normal WECB funding process to acquaint persons involved in distance education with the arcania of the genre:
  - A codec "shoot-out" involving several manufacturers and data rates in order to determine the acceptability of different standards for instructional purposes and administrative teleconferencing
  - A "demand service" link employing several codecs, including the recently-announced low cost CLI codec using multiple DS-0s, as well as dedicated DS-1 standard

4.5 Benefits and Risks

If the technologies, methods, standards and roles outlined above are followed by the state and the local institutions, the result will be a statewide information highway which will meet all of the needs identified in Chapter 2. This highway will not only enable voice, video and data communications between identified institutional endpoints in the state but will also allow for bidirectional access of resources both nationally and internationally.

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[1] This is the time period during which the telecommunications vendors will be deciding where to locate their wideband switches for most efficient service.

In brief, without re-stating the needs previously identified in Chapter 1, the proposed overlay network will allow all parts of the state and the vast majority of its population the opportunity to take advantage of educational and training resources from many diverse sources. Use of an extended two-way teleconferencing ability will reduce travel costs for educational institutions and state agencies and will enable a higher level of employee training than is currently possible.

Implementation of the recommendations will result in a statewide voice, video and data highway which will meet all of the identified needs.

The existence of an information technology highway is steadily becoming a more important factor in the relocation plans of high-profile corporations. Establishment of the overlay network therefore dovetails well with the goals of the Department of Development as well as the Manufacturer's and Commerce Association.

The primary risk which is associated with the establishment of the overlay network is that selected technologies will be obsolete before they can be fully amortized. Following the implementation plan outlined in this chapter, and the migration plan to be presented in the next chapter, the presence of frequent "reality checks" and the presentation of alternate entry points in the implementation flow chart should minimize this risk to the point where it is insignificant compared to the enormous benefits which would be realized.

The main risk is that technologies will become obsolete before they can be amortized.

4.6 Process To Keep Information Current

One of the specific missions of this phase of the study is to recommend actions through which the WECB and other agencies can maintain the currency of information produced by this study and remain up to date in the rapidly changing distance education field. This section will discuss ways in which such updating can be accomplished.

4.6.1 Keeping Current With Technology

4.6.1.1 Current Activities

4.6.1.1.1 Background

WECB, through the efforts of the Educational Services Division and in particular the Bureau of Distance Education Technologies (formally the Bureau of Narrowcast Services) has been continually involved in activities that relate to distance education over the past decade. During that time WECB has posted many milestone achievements with respect to distance education technologies that were broad in scope and

Keeping current with the latest developments and technology and in local issues are critical to the ongoing sucess of a statewide initiative.

edge-of-the-art. Today, a more unified structure is being focused on distance education activities through Educational Services via strategic planning initiatives.

WECB's current and past activities in staying current are oulined.

In the past, the WECB staff did their individual best to keep current with distance education technology by involving themselves in distance education activities such as symposiums and conferences as the opportunities presented themselves. With the exception of a few projects, the efforts that have taken place in the past would be considered more informal than structured and planned. It is expected that keeping current will be even more difficult now that a staff cut has been ordered.

4.6.1.1.2 Duties and Accomplishments

During the past decade WECB has made many significant contributions to the development of distance education in Wisconsin. Some of these accomplishments include:

1). The distance education experience began with the initial ITFS pilot project in 1986 and the subsequent development to 18 ITFS sites today.

2). Organization of User Groups (consisting of representatives from VTAEs, CESAs, K-12s and UW) by the Narrowcast Assistants to assist with facilitating local and regional system development, program planning and scheduling.

3). WECB was a founder of SERC (Satellite Educational Resource Consortium) in 1986 and has been an active promoter since that time.

4). WECB partnered with DPI and UW-Extension to provide SERC staff development programs.

5). Since 1989, WECB has been operating Wisconsin's first publicly owned and operated TV uplink facility in the state. This facility is used to originate programming to the National Technological University (NTU), SERC and statewide Cooperative Extension events.

6). In the past several years WECB has been involved in numerous administrative meetings:

- WECB staff serve on the steering committee of the annual distance learning conference. This is an international conference.
- In 1989, WECB organized the first statewide distance education symposium. This event is now co-sponsored with DPI, VTAE, and UW Extension. These conferences focus on "hands-on" sessions featuring Wisconsin presenters, and provide an excellent opportunity for distance

educators to network among their peers as well as for novices to get practical exposure in order to learn about distance education techniques in Wisconsin.

- An ITFS User Assembly comprised of representatives from WECB-sponsored ITFS systems was organized by the WECB Distance Education Technologies Department.
- The WECB Engineering Division recently sponsored a statewide technical conference on distance education technologies.

7). WECB operates an interactive computer system called Learning Link that includes a database on instructional television resources, as well as forums on many topics including narrowcast user groups, distance education networks and equipment, distance education technologies studies, symposium planning, and satellite teleconferences. This year WECB secured outside funding to provide toll-free services to Learning Link.

8). WECB executive and education staff make speeches and presentations and participate in a variety of organizations in which distance education is a focus such as the Regional Educational Telecommunications Area Advisory Committee, the VTAE Media Consortium, the UW Media Council and the UW Faculty College.

9). WECB will be participating in the VSAT (Very Small Aperture Terminal) pilot project in conjunction with PBS, UW - Madison College of Engineering Information Technology Department, and the Waunakee School District.

10). WECB initiated, coordinates and facilitates the work of the Distance Education Technology Initiatives Committee (DETIC). This committee advises the WECB Board on matters concerning distance education issues and directions.

11). WECB has on staff many individuals who have responsibilities that have a direct impact on the development of Distance Education in Wisconsin. This staff manages and provides maintenance for the statewide ITFS network and the TV/FM interconnect network, among other duties. Beginning with the WECB Executive Director and the Deputy Director, other involved positions include:

- The Administrator of the Educational Services Division.
- The Director of the Office of Technology Services.
- The Chief Engineer of the Distance Education Technology Services and the five Regional Distance Education Technologies Service Engineers.
- The Director of Distance Education and the three Regional Distance Education Consultants.
- The Directors of Educational Programming, Telecommunications Services, Research and Instructional Programming.
- The Manager of School Services.

A formal distance education structure is beginning to evolve at WECB. WECB Educational Services Division has projected a firm set of distance education related activities in the "Long Range Goals" and the

"One Year Objectives" sections of the recent WECB 1992-93 Long Range Planning document. The current and projected activities of WECB in the area of distance education will enhance the efforts of the Director of Distance Education Technologies and the Advisory Committee.

In an effort to keep current, the WECB staff collects distance education and other agency impact information from various bulletin boards and print media subscriptions. This information is shared informally among staff members.

WECB also schedules periodic meetings with various service providers such as Access Wisconsin, MCI and other vendors involved in the distance education environment. The purpose of these meetings is to keep abreast of their efforts and the state of the industry. These meetings are generally informal and are not held on a regular basis.

Interactive video distance education is an emerging technology and many meetings are beginning to be held throughout the industry at various locations across the country. However, budget constraints have restricted travel outside the State of Wisconsin in order to attend meetings. Consequently, very limited travel for the purpose of attending distance education meetings occurs at the present time. In-state travel consists of work related meetings with agency committees, distance education consortiums and vendor meetings such as WSTA meetings.

WECB has recently joined the United States Distance Learning Association but does not belong to any other organizations or associations that are specifically focused on distance education techniques, technology, planning, or managerial issues.

Currently, for the benefit of the general staff, WECB subscribes to the usual array of telecommunications and broadcasting trade journals, magazines and newsletters. The current list of publications includes: Broadcasting, Cable Action Update, TV Action Update, Channels, CPB Manager's Clips, CPB Report, PBS Report to Managers, ETV Newsletter, The Public Broadcasting Report, Television Digest, Trend Letter, Video Week, Via Satellite and Electronic Media. Articles of interest are noted and or copied and distributed to interested individuals on staff.

4.6.1.2 Recommendations for Keeping Current on Technology

As part of this study, a suggested representative list of conferences, organizations, magazines and other information sources has been compiled. This data is being incorporated into the computer database (along with the computer modeling software) and will be made available by WECB in electronic form to distance education users and other interested parties throughout the state. A description of the database information is provided as Appendix Q.

This section discusses recommendations for enhancing staff knowledge of current events. Although the focus is on WECB as an agency, the recommendations also apply to each of the participating partner agencies and institutions. Because each agency will be responsible to its own constituency, keeping current through means of the recommended conferences, meetings, trade journals and by active participation in associations will apply to greater or lesser extent.

4.6.1.2.1 Conferences

It is recommended that WECB attempt to make funding available which would encourage attendance at selected regional and national distance education conferences. Some of the suggested meetings, conferences, workshops and seminars are listed in the study database.

4.6.1.2.2 Organizational Membership

There are many fine existing and emerging organizations focusing on distance education activities and issues. The information these organizations make available and the human network opportunities they provide make active membership an important element in the statewide distance education effort. A suggested list of organizations to investigate is included in the study database.

Three ways to keep current are through conferences, organizations, and magazines.

4.6.1.2.3 Magazines

On every front, telecommunications is a rapidly changing industry. Keeping abreast of the constantly changing technologies is a very important and difficult thing to do. Keeping up to date can be an "embarrassment of riches". While the print media does a generally good job of presenting and discussing a wide variety of issues, magazines and trade journals take a considerable amount of time to read and to process all the information presented. Not only is information overload a problem, the issue of sorting, filing, maintaining, and destroying outdated and useless information can be daunting.

As a result it will be important for the Director of Distance Education Technology to carefully select magazines and newsletters that specifically focus on distance education, and to target these publications directly to the persons who can use the information. The challenge for effectively keeping track of information will be in the selection of the most pertinent publications. The database associated with this report contains a short list of suggested reading material that should be thoroughly reviewed. The list does not purport to be all-inclusive, however. As a routine activity, the Director of Distance Education Technology should be continually searching out and reviewing various print media resources that can possibly be added to or substituted into the list used in order to more effectively track distance education technologies.

4.6.2 Keeping Current With Standards & Regulations

4.6.2.1 Present Activities

The WECB Staff makes an effort to monitor the PSC and its regulations. This is a very important activity because of the rapidly changing regulatory environment. The WECB, through membership in the Telecommunications Advisory Committee, also has regular contact with representatives of the Department of Public Instruction and the Department of Administration. Liaison with the FCC is accomplished via the Washington D.C. communications attorney and the Consulting Communications Engineering firm.

4.6.2.2 Recommendations

Among the steps WECB should investigate in an effort to stay current in the area of standards and regulations are the following:

Several outside groups can be used to assist ECB in keeping current with changing standards and regulations.

- The Washington Information Group is a service which will scan federal publications and feed back to the subscriber those papers which relate to sets of criteria defined by the subscriber.
- WECB already uses the services of a Washington D.C. attorney who provides information on broadcast and ITFS matters. Continued use of this resource is encouraged, although the scope should be expanded to other technologies.
- Continued use should be made of FCC Engineering Counsel.
- Contact should be maintained with major vendors, IEEE, PSC, NAB, EIA, and the FCC for the purpose of keeping abreast of changes in standards.
- WECB is encouraged to participate in the activities of the national trade associations such as NAB, NPR, ICA and those organizations listed in the previous section on keeping up with technology.

4.6.3 Keeping Current With Local Developments

4.6.3.1 Current Activities

To keep current with local developments, WECB works with planning groups, meets with user groups and provides information when it is requested. WECB also becomes aware of local plans via information resulting from newsletters, audio conferences, meetings, and day-to-day business contacts.

4.6.3.2 Recommendations

ECB's current efforts are felt to be effective in keeping current with local issues.

It is felt that the problem of keeping current with local developments in distance education will be substantially met through the creation of the Distance Education Technology Committee as outlined above . These organizational steps, in conjunction with those already set in place by WECB, should allow full monitoring and support of local planning initiatives.

Local and regional network managers should be contacted periodically to ensure that effective two-way information interchange is taking place.

4.6.4 Financial Modeling

4.6.4.1 Introduction

During the investigation of the alternatives presented in this document, a financial model was developed and used to compare the costs of the alternatives. This model was created with the following goals in mind:

- That it help organize the large amount of pricing data collected.
- That it allow the user to create custom configurations for the interconnect network.
- That it allow simple, straightforward modification of any configuration.

As part of this project, a financial model has been provided to ECB to help in pricing systems.

Before the model was created, several scenarios for possible use were considered. As an example, assume that it was desired to price out an interconnect network consisting of a DS-3 between Madison and all TV endpoints, and a DS-0 between Madison and all radio endpoints. The model should easily allow the pricing of this configuration. Then, it should be possible (and relatively simple) to substitute a DS-1 circuit for the DS-0 between Madison and Green Bay and see the impact on the price. This type of activity was the goal for the model.

Creating a model such as described above will allow WECB to continually evaluate alternatives for the interconnect as the costs and capabilities of different technologies changes.

4.6.4.2 Components Of The Model

The model which was created is based on a set of computer spreadsheets. Per the wishes of WECB, these spreadsheets were created using the Microsoft Excel software package (although the spreadsheets may be directly converted to other formats such as Lotus 1-2-3). The spreadsheets were created using Version 3.0a of Excel and may also be used by the new Version 4.0.

This model is based upon a set of EXCEL spreadsheets. They allow the user to design and change proposed networks using a database of prices collected during the study.

The costs which WECB could incur in the creation of a new interconnect system were first divided into three areas: route costs (e.g. paying for a DS-3 circuit), equipment costs (codec, antenna, radio) and other costs (consulting fees, maintenance contracts, personnel). A spreadsheet was developed for each of the route and equipment areas. These spreadsheets have the same structure (i.e. same number and size of columns). Each of these spreadsheets was filled in with all the pricing data collected during this phase of the study. For example, all of the circuit pricing information received from MCI was entered. One row of the spreadsheet might give, for example, the cost of a fiber DS-3 between Madison and Milwaukee. This cost would include both the recurring and non-recurring charges. Another line might give the same route (Madison to Milwaukee) but the costs would reflect a five year lease rather than a three year lease. In this way, each separate network component was added to the spreadsheets.

In addition to the route and equipment data, the third component of the model is another spreadsheet we call the "model". The model spreadsheet is divided into three sections: route, equipment, and other costs. The structure of the model is identical to the other two spreadsheets. The model contains no data. Rather, it allows for data to be put into it, as described below.

4.6.4.3 How The Model Works

The model separates costs into three areas: route costs, equipment costs, and other costs.

Users "cut" and "paste" items onto a blank model to create a price scenario.

The model is used in the following way: first, the user opens up all three spreadsheets in Excel. Then, the user goes to the route and equipment spreadsheets and, using the "cut" and "paste" functions, chooses the options (i.e. rows) to be considered and transfers them to the empty model. As many rows as are necessary may be put into the model. The model spreadsheet will subtotal and total the recurring and non- recurring charges, giving a total cost figure for this configuration. Once all of the desired route and equipment options have been transferred to the model, the user may add charges into the "other" section as appropriate. The model can then be saved using a different file name (so that the blank model is not overwritten). At any later time, the selected configuration can be modified by adding, changing, or deleting items (rows) from the chart. An example of the filled-in model is provided as Appendix P to this report. These examples show some of the alternatives for the interconnect which were discussed earlier in this document.

4.6.4.4 Keeping The Model Current

The costs which have been put into the route and equipment spreadsheets were those provided to this consultant by the providers (MRC, AT&T, and others). These prices are, of course, subject to change at any time. In order for the model to remain viable the prices must be kept current. During the course of the *Distance*

Education Study, a Request For Information (RFI) was issued to the bandwidth providers in order to evaluate the status of the Wisconsin infrastructure and to obtain order of magnitude costs.[1] This sort of annual polling of the route and equipment providers would yield the data necessary to keep the model up to date.

For the more advanced Excel user there is a different way to use the model which would result in a far easier update process. The method for using the model described above involves "cutting" the desired data from the prices spreadsheets (i.e. routes and equipment) and "pasting" them into the model. If a price were to change, it would then have to be changed not only in the prices spreadsheets but also in any model that was created using that old price. If many prices changed, this would result in very time-consuming updates. Alternatively, models could be created which do not make a copy of the data in the price spreadsheets. Rather, using the Excel LINK feature, the model could retrieve the desired data from the price spreadsheets every time the model is opened on anyone's computer. This means that changing a price on the route or equipment spreadsheets would result in automatically updated prices on all electronic copies of the model which exist. This would *greatly* ease the update process.

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[1] A copy of this RFI and the responses have been presented to the WECB under separate cover.

5. Order Of Magnitude Costs

5.1 All Fiber System

Order of magnitude costs for one-time construction of a total fiber optic system were calculated for the three major network elements. The costs were developed based on first hand knowledge of costs for similar systems in Wisconsin and other states, augmented by budgetary pricing provided by utility vendors. Where information was incomplete or unavailable, engineering estimates were made based on professional experience and judgement. Prices reflect probable estimates of what might be expected on a statewide project of this magnitude.

Summary costs for a complete, statewide fiber network to all state schools and libraries is given.

The fiber cost estimates assume that the Tier 1 overlay network would be initially capable of carrying six DS-3 two-way channels, with one DS-3 delivered to each institutional user. For the purposes of this cost scenario, it will be assumed that the video portion of the DS-3 requires 36 MBs, leaving additional room for four DS-1 channels as well as several voice and data circuits. Special considerations for the TV and FM overlay network will be discussed in the next chapter.

The costs detailed below are based on a typical ten year contract from a utility vender. Cost figures reflect pricing in 1993 dollars.

5.1.1 Fiber Cost Summary

- Local Network connections = $122 Million total cost.
- Regional Systems = $51 Million total cost.
- State Overlay Network = $53 Million total cost (including estimated discount from $80 Million due to one-time construction).

The total estimated fiber network cost is therefore $226 Million.

The estimated cost for the local and the regional portions of the network were made assuming that all 1,270 elementary schools and 377 public libraries are to be connected to the local network portion of the system. For high schools, it was assumed that 428 of the 758 public high schools would be part of regional networks, while 330 would represent local connections. All remaining entities were considered to be part of the regional networks.

The overlay transportation system cost is based upon the facilities required to tie the regional switching clusters together.

5.1.2 Network Cost Breakdown by Institutional Group

Costs are broken down by institution groups in this section.

The proportionate share of the fiber network costs for each class of institution is approximately as follows:

- 758 High Schools = $71 Million.
- 1270 Elementary Schools = $76 Million.
  - Subtotal = 2028 Schools = $147 Million
- 16 Primary VTAE Campuses = $2 Million.
- 40 Satellite VTAE Campuses = $5 Million.
  - Subtotal = 56 Campuses = $7 Million
- 26 UW System Campuses = $3 Million.
- 21 Independent Colleges = $2.5 Million.
- 17 System Libraries = $2 Million.
- 377 Public Libraries = $23 Million.
  - Subtotal = 394 libraries = $25 Million
- 12 CESA Offices = $1.5 Million.
- 72 County Seats = $6 Million.

The total cost is therefore $192 Million for 2,609 educational entities. Adding a network management and maintenance cost of $34 Million brings the grand total to $226 Million. At the present time, approximately $25 Million worth of fiber projects are in various stages of development.

It should be noted that these costs reflect current non-discounted vendor practices and PSC regulations currently in force. A combination of existing fiber and new fiber is assumed where required, and all required switching and concentrating equipment has been included as required.

It should be noted that the final statewide overlay network may have additional requirements and features which are not reflected in these cost estimates. For instance, equipment for dynamic bandwidth control may add some cost to the system. On the other hand, if the proposed network was to be used for other purposes, such as to carry Statewide Telephone System or CDN traffic, or if discounts are available through centralized leasing and the relaxation of PSC regulations, the cost could be lower than indicated.

In any case, it is obvious that a user-to-user fiber network funded completely by the state is not a practical solution. For the three-tier overlay network only, the state costs are estimated at $85 Million over 10 years including an increase in capacity to 12 channels during the 10th year. All switching equipment, network maintenance, and overhead is also included.

Using the State/Local dichotomy of responsibility, it is expected that local tail circuits would average $100,000 to $300,000 over ten years. This would cost from $900 to $2,500 per month, with network usage costing another $1,000 per month per high-cap DS-3 channel.

5.1.3 Voice/Data Capability

The cost estimates for a statewide distance education network utilizing fiber optic facilities are based on a DS-3 network using the video service scenario. Estimated costs assume a single two-way digital video channel at each location. State Overlay Network segments assume a minimum of two DS-3s. Sufficient excess capacity exists in the overhead of each DS-3 channel to carry up to four DS-1 (DS-1) channels. To add a minimum of two DS-1 channels to each of the 2,609 locations on the proposed statewide network would cost an estimated additional $50 Million.

Assuming that a bandwidth oriented scenario is in force, as recommended by this study, there would be sufficient capacity on the network to transmit the initially anticipated data with no increase in cost over the $85 Million already indicated.

5.2 ITFS

Supplementation to the existing state ITFS system would cost a total of $16.8 million.

To employ ITFS as the only component of a statewide system would not be possible from the standpoint of frequency allocations. Typically an ITFS transmit site costs approximately $90,000 plus tower. If an average 400' tower with shelter is assumed, the total transmit site costs would be approximately $160,000. There are approximately 50 locations throughout the state where ITFS transmitters could be added to the existing complement in order to deliver four to eight channels to an area of approximately 700 square miles. This would cover a total of approximately 70% of the population of Wisconsin on a last mile basis, for a total new facilities cost of $8 Million. Assuming each site served an average of 12 schools, the total receive cost, at approximately $8,000 each, would be approximately $4.8 Million, for a total of $16.8 Million, including upstream audio capability, a monitor and network management.

As an interim portion of the last mile network component, however, it is anticipated that there is allocation room for approximately three ITFS projects in geographic areas sufficiently removed from cities with a population of over 20,000 persons.

5.3 Microwave

Microwave links can be used for both portions of the backbone and for certain last mile applications.

5.3.1 Overlay Network

There are 48 existing Department Of Transportation tower sites which could be used for the overlay network. Adding 17 Department of Natural Resources tower sites, three WECB sites and six new sites yields a total of 74 tower sites which could be used to form a system backbone using the 2 GHz and 6 GHZ frequencies. Two DS-3 digital radio terminals, complete with antennas and transmission line, cost approximately $70,000 each, for a total cost of $5.18 Million.

Making full use of existing state microwave resources, it would cost approximately $12 million to complete the overlay network using microwave.

Following a frequency allocation study, it is likely that some higher frequency bands will be required in the 18 GHz range in order to interconnect some tower sites. As an estimate, this would require another 20 new sites because of the shorter range of the higher frequency. The cost associated with this factor would be approximately $1.6 Million.

Assuming that each tower site would require a stress analysis and a certain amount of strengthening, an additional $600,000 should be added. Multiplexers and control equipment would cost an additional $2 Million, while consulting time would be approximately $150,000. Adding costs for network management yields a total cost of $12,389,000. It should be noted that DOT microwave towers are not co-located with fiber POPs and therefore direct comparisons should be made with caution.

In addition to the backbone costs, individual endpoints would require an investment of approximately $50,000 for a receive-only link, and approximately $170,000 for a two-way link.

To establish the complete three-tier overlay network using microwave would not be a good use of resources. It is recommended that microwave be used only for low-capacity links where light fiber is not cost effective.

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5.4 Satellite

Satellite costs are provided.

5.4.1 NTSC Satellite

Approximate current transponder costs are given as follows:

- C-band = $325 per hour.
- Ku-band = $500 per hour.
- AT&T Telstar 401 = $5 per hour + uplink and decoder costs (total of approximately $8 per hour over ten years for one-way service).

These costs should be compared to approximately $13 per hour for the fiber solution.

5.4.2 VSAT Satellite

VSATs are usually installed on a five-year lease arrangement. Equipment capital costs are approximately $13,000, with monthly fees averaging $50 to $80 for the space segment, and $50 for the pro-rated hub share. Data rates of either 56 KBs or 128 KBs can be employed, and SCPC full motion video can be added to the VSAT by installing a 3.5 meter dish for an additional capital investment of $25,000.

Currently, service is only available to users requesting more than 50 endpoints. NPR is looking into the possibility of establishing a hub control station which could be used by members proposing a fewer number of sites.

This section provides yearly cost estimates for developing the network

5.5 Order of Magnitude Costs For Phased Multi-Technology Approach For The State Overlay Network (Recommended Option)

The summary costs given below refer to the recommended method of establishing the overlay network, and were developed based on first hand knowledge of what is being charged for similar systems in Wisconsin and other states.[1] In addition, a substantial degree of budgetary pricing was provided by utility vendors. Where information was incomplete or unavailable, engineering estimates were made based on professional experience and judgement. Prices reflect probable estimates of discounts which might be expected on a statewide project of this magnitude.

State funding and construction supervision of the overlay portion of the statewide network would cost approximately $80 to $100 Million (Net Present Value) as the network is currently envisioned, including incorporation of existing operating routes (such as existing distance education systems and the broadcast network). This is the recommended option, which would be the end product of a migration strategy encompassing approximately ten years. This estimate consists of the following components:

- Detailed network design by a communications consultant.
- Generation and evaluation of RFPs.
- Construction supervision, contract maintenance and performance proofs.
- Continuing network administration and maintenance.

This cost estimate does *not* reflect income resulting from charges for network services. Such income is subject to many unknowns and contingencies. However, assuming the best scenario with motivated personnel at all levels, the following cost schedule represents a *possible net cost scenario*:

1994 Expenditures = 1.2 Million for overlay network

1994 Expenditures = 1.0 Million for local seed money
Income = 0.1 Million

1995 Expenditures = 2.0 Million for overlay network

1995 Expenditures = 2.0 Million for local seed money
Income = 0.5 Million

1996 Network Expenditures = 5.0 Million
Income = 1.0 Million

1997 Network Expenditures = 10.0 Million
Income = 2.5 Million

1998 Network Expenditures = 18.0 Million

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[1] Of course, some of these fiber routes are already in place and being used by local consortia, but such resulting cost savings would be substantially offset by the accommodation of the increased traffic generated by other entities. If a complete "last mile" network was implemented immediately, the contracts for these existing routes would need to be "bought out". In any case the total state-run fiber solution, including the "last mile" connection to the end user, is not recommended both because of cost and because of the local/overlay dichotomy.

Income = 4.0 Million

1999 Network Expenditures = 22.0 Million
Income = 6.0 Million

2000 Network Expenditures = 20.0 Million
Income = 7.0 Million

2001 Network Expenditures = 15.0 Million
Income = 8.0 Million

2002 Network Expenditures = 12.0 Million
Income = 8.5 Million

2003 Network Expenditures = 10.0 Million
Income = 9.0 Million

2004 Network Expenditures = 9.0 Million
Income = 9.5 Million

2005 Network Expenditures = 8.0 Million
Income = 10.0 Million

The continuing administration of the network is expected to cost the state approximately $8 Million per year in terms of present dollars subsequent to the year 2005.

This estimated scenario does not include the cost of money, but it does include some user seed money and a 47% increase factor in cost due to increased participation in the network once construction is under way.[1]

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[1] It is a fact of life that once a technology becomes commoditized, many people who may have underestimated its uses previously (as in the *Needs Assessment*) will find that they can indeed utilize it. The FAX machine is a good recent analogy.

6. Migration and Implementation

This chapter of the Distance Education Study document presents a plan for implementing the technologies previously recommended as suitable for use by the Wisconsin Overlay Network. The respective roles of the local institutions, consortia, and Wisconsin state agencies will also be explored. A migration scenario and an accompanying timeline will be introduced.

This section recaps the technology recommendations for the local, regional, and overlay networks.

A comprehensive set of standards will be tabulated for use by designers of distance education and business video, data and voice systems. These standards will ensure compatibility of regional and local networks both with respect to each other and with respect to the statewide overlay network (see Appendix R, attached). This information will assist the educational institutions of the state in formulating strategic directions for the development of distance education technologies, and will provide a base from which future updates may be made.

6.1 Summary of Technology Recommendations

The technology choices available to the designer of distance education systems have been detailed in previous chapters of this document. The following discussion provides a summary of the recommendations concerning which technologies are best suited for each of the identified network elements:

- The **Local Network.**
- The **Regional Network.**
- The **State Overlay Network.**

6.1.1 Recommended General Capabilities

At this early stage in the development of telecommunications networks, it is tempting for educational institutions to under-estimate the communications capability they will require. Because DS-1 circuits cost approximately one-tenth as much as full DS-3 connections, there is a strong incentive to attempt to fit one's video, data and voice requirements into the smaller pipe represented by the DS-1. In many cases, however, such effort will be doomed to immediate insufficiency in the same manner as a computer which is purchased today with a low-cost 10 megabyte hard drive.[1]

Sub-DS-1 restricted-motion teleconferencing and computer data transfer rates which are barely tolerable now will become intolerable for most users in the near term, especially when multi-media graphics and video displays become the accepted communications norm.[2]

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[1] A real world illustration may be instructive in emphasizing this point. At Indiana University in Bloomington, a professor of high-energy Physics continually complained that his DS-1 NSF supercomputer connection to Champaign was too slow. After verifying that the link was indeed operating correctly, it was calculated that he could load his tapes into a station wagon and drive them to Champaign before all the data would arrive on the DS-1. Keeping such experiences in mind, the University of Wisconsin's proposed new Champaign link will be capable of 688 Mbs. Computer users should appreciate the fact that it requires the *entire* capability of a DS-1 to connect a remote workstation to a PC-WAN so that the workstation will operate with a speed approximating that enjoyed by the directly-connected network workstations. Since many colleges and universities today are wiring their campuses for *FDDI* (Fiber Digital Data Interface) or *ATM* (Asynchronous Transfer Mode) fiber and Level 5 twisted copper pair, it does not make sense to reduce the local transfer speed of 100 Mbs or greater to 1.5 Mbs when communicating with computers via long distance, even assuming data compression can be used. As a further factor, one primary rate ISDN signal requires a full DS-1 to carry it; this would provide a full videographics display for only one computer workstation, for instance.

[2] For instance, an internal study conducted by the Appleton campus of the Fox Valley Technical College concluded that there was an immediate need for 4 Mbs computer data connections, and a longer-term need for 100 Mbs.

Given these facts, it is recommended that DS-3 capability be sought from the outset for *every Wisconsin institution* desiring to participate in the distance education revolution, and to connect to the overlay network. If such capability is beyond budget reality, then DS-1s should be utilized only with the understanding that a clear future migration path must be established. One method of assisting such migration is to either sign a relatively short lease for the DS-1, or provide a means for economically re-sizing capability during the lease term.

It is recommended that DS-3 capability to each institution be planned.

In a similar manner, the temptation may be strong for the designer of local or regional networks to take shortcuts with respect to network topology or switching implementation. For instance, a *scanned network* is initially less expensive than one which offers a continuous view or quad split view of each remote site. However in many cases (especially when these systems are used in an intensive interactive mode), some instructors and students can tire of scanned systems, which seem to disrupt the even flow of information interchange. Scanned systems also do not offer the multi-station immediacy which some users have begun to expect from the UW's audiographics distance education system.[1]

Continuous view monitoring is recommended.

For the last mile networks, it is suggested that "loop-through" technologies be avoided since they do not migrate well.

There is one other important consideration with respect to the cost of distance education systems. Both local and state-level budget analysts have a tendency to concentrate only on the *debit* side of the distance education ledger. Quite apart from ethereal promises of higher educational efficiency and a more productive future workforce, there are real and tangible opportunities for *income production* inherent in the interconnections which make up any wide area distance education system:

Programming developed for distance education networks can produce income.

- Existing on-campus credit courses can be extended off-campus to reach additional and non-traditional students for more income per course.
- Unique documentaries and lecture series can be distributed nationwide and worldwide.

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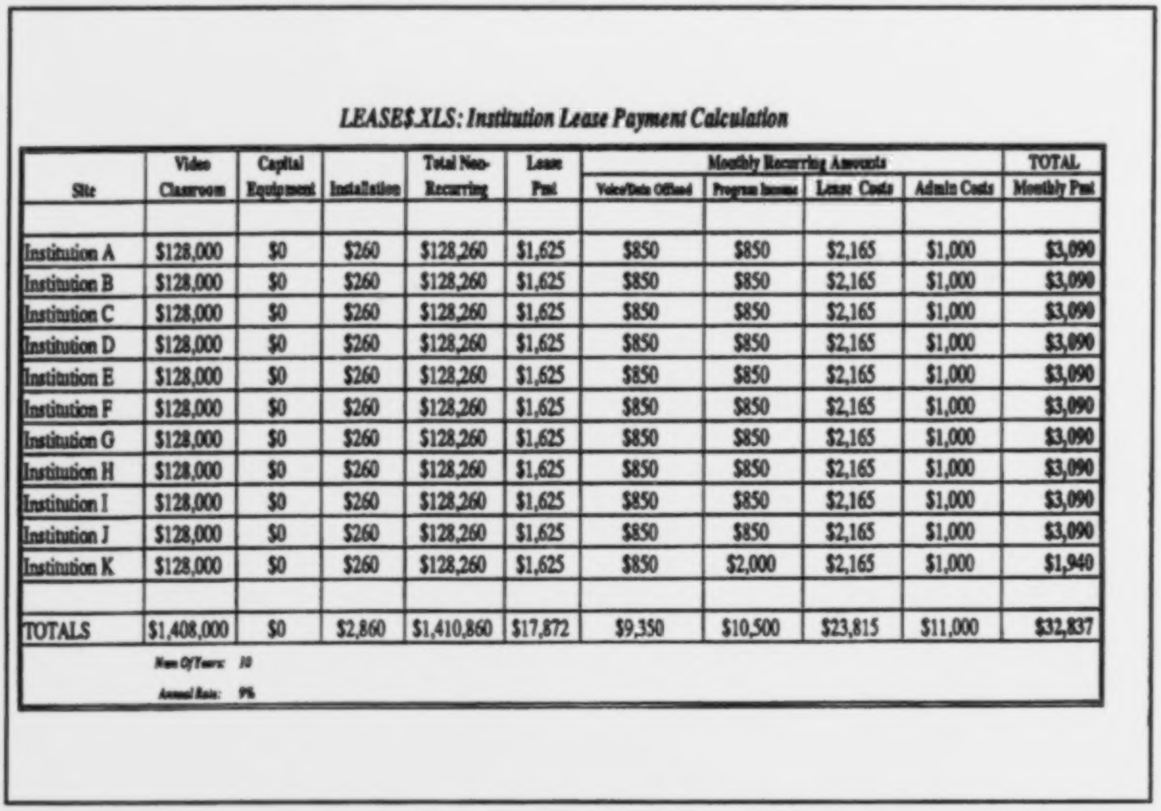
[1] There are two "scanning" systems installed in Wisconsin at the present time. The consensus on these systems seems to be that, after an initial period of discomfort, an acceptable accommodation can been reached with the scanning technique for instructional delivery, although teleconferencing with three or more parties is operationally difficult. In the opinion of this consultant, the discomfort level will steadily increase as more sites are added. However, in consideration of budget realities, the addition of an audio bridge to these scanned systems will undoubtedly improve their user acceptability. As with the DS-1 mode, if the choice is between a scanned system and no system at all, the scanned system may be initially acceptable if a clear upgrade path for both hardware and software is available at a reasonable cost in the future.



LEASE$.XLS: Institution Lease Payment Calculation

Site	Video Classroom	Capital Equipment	Installation	Total Non-Recurring	Lease Pmt	Monthly Recurring Amounts				TOTAL
						Voice/Data Offload	Program Income	Lease Costs	Admin Costs	Monthly Pmt
Institution A	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution B	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution C	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution D	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution E	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution F	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution G	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution H	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution I	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution J	$128,000	$0	$260	$128,260	$1,625	$850	$850	$2,165	$1,000	$3,090
Institution K	$128,000	$0	$260	$128,260	$1,625	$850	$2,000	$2,165	$1,000	$1,940
TOTALS	$1,408,000	$0	$2,860	$1,410,860	$17,872	$9,350	$10,500	$23,815	$11,000	$32,837

Num Of Years: *10*
Annual Rate: *9%*

Figure 6.1

- Training courses offered at business workplaces, perhaps using audiographics, have high income potential.

In addition, savings can frequently be realized by incorporating telephone service, FAX machines and computer connections on the network.

The example spreadsheet of Figure 6.1 illustrates a possible evaluation tool which can be used to determine the approximate net final monthly cost to the end user of a hypothetical distance education system.

There is one major caveat with respect to the income-producing potential of distance education. The setup, production, and effective use of telecourses is entirely dependant upon the tenacity and creativity of the people in charge of the project. Unlike some other educational initiatives, which can more or less proceed on the basis of their own momentum, the management of telecourse production requires single-minded dedication and a willingness to overcome the choruses of "yes buts" which accompany any paradigm shift of this magnitude. One dedicated person can successfully shepherd a project, but a media director or an administrator who is not quite so committed will cause the fledgling enterprise to be stillborn.[1]

Therefore, one of the first and perhaps the primary dependency of the statewide distance education initiative is to place the right people in the right places, both locally and at the affected state agencies. These people can act as "idea champions" to catalyze others to action.

6.1.1.1 Detailed Technology Recommendations For The Local Network Element

6.1.1.1.1 Recommended Technology Choice Set

For the local network consisting, for instance, of a University Center or a VTAE College connected to its remote campuses, it is recommended that a mix of technologies be employed depending upon the following availability of local resources (in the approximate order of preference):

For local networks, a technology mix based on available resources is recommended.

Digital light fiber provided by regulated or unregulated common carriers is to be preferred if it is installed in place with terminal switching equipment available, and is otherwise cost-effective. This method of transmission has been shown to be extremely reliable while imposing a minimum operational load on the user (see Appendix D, attached).

Digital microwave transportation provided by **unregulated carriers** (such as the Wisconsin DOT or MRC) would be the next best choice if established nodes could be linked in a single hop. This electronic transportation method can be just as reliable as digital light fiber if the system is properly designed, but channel availability is limited in some areas.

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[1] The most famous positive example is the MBA program which is delivered by satellite from Ball State University in Muncie, Indiana. The brainchild of one business school professor, it survived a Quixotic charge into the bureaucratic gauntlet to become a reality.

Analog light fiber is the next most effective local technology[1], usually provided by the local cable companies. The Cable TV option has a somewhat spotty reliability record in general, but cable maintenance and the average technician skill level have been recently improving to the point where single-franchise local distribution is feasible.

Networks which require the cascading of more than *ONE* Cable TV company to reach the desired endpoints should *not* utilize Cable TV technology at the present state of development because the chances of maintenance-related failure is excessively great. In addition, a multi-Cable solution results in distributed responsibility which causes maintenance difficulties, especially at the system interface. Some local telephone companies are also providing analog light fiber, but pricing of the last mile piece frequently is quite high.[2]

Analog microwave transportation provided by **unregulated carriers** (such as the Wisconsin DOT or MRC) would be cost-effective if limited capacity is not a problem and cost is the overriding concern (one full motion analog NTSC channel and one DS-1 can usually be established this way in geographic areas outside of Milwaukee, Madison, the Fox Valley area, and Green Bay - see Appendix D). The cost effectiveness assumes that established nodes could be linked to the end user in a single hop.

Digital microwave provided by the **users themselves** is the next most efficient technology, particularly when used in conjunction with IXCs such as AT&T, MCI and Sprint among others.[3] FCC Regulations

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1. FM modulation technology is to be preferred for its greater video and data fidelity, but many Cable companies offer only AM modulation. Although AM modulation may not be quite as noise-resistant as FM, it frequently has the overriding advantage of being less expensive for the user. In any case, the use of AM is not fatal, since it can migrate to FM when the need arises.
2. PSC regulations require the pricing of analog fiber to be based upon the fraction of total capacity used by the customer. Since analog modulation uses a larger fraction of the cable's total capacity than does digital modulation, the user's lease cost goes up even though the terminal equipment is much less expensive.
3. During the course of the *Needs Assessment*, some users opined that what they "needed" was light fiber. Rather than focusing on the *means* of transport, users should intimately define their *requirements* and let the technology choice be based upon present and future needs as well as costs. In many cases investigated by this consultant, a tough-minded engineering analysis shows that where new fiber must be laid, a microwave system can be paid for in only one or two years; subsequently, the user can join the fiber network five to eight years in the future when the costs are lower.

provide the *Private Microwave Radio Service*, which uses the 18 GHz and 23 GHz frequency bands to provide last mile connections of up to 12 miles in length. Use of private digital microwave results in a maintenance burden on the user, which is usually resolved by contracting with an outside firm. These systems should be amortized in no more than eight years to ensure cost-effectiveness.

Point-to-Point Analog Microwave provided by the **users themselves** can be a low-cost solution if its limitations are kept in mind. AM-modulated analog microwave, such as the CARS band used by Cable TV companies and point-to-point ITFS microwave, can be installed for less than $100,000 per endpoint. These technologies are not conducive to carrying computer data, however. It should be assumed that these types of microwave systems will be fully paid for in no more than five years so that a switch to another technology can be made before demand outstrips capacity.[1]

Satellite can be effectively utilized for occasional uplinking, through either a portable uplink or a microwave connection to a common carrier. The downlink required to utilize broadcast programming is very inexpensive and may be permanently installed. In many cases involving sophisticated users, a satellite interconnect is installed in addition to other networking technologies in order to increase system flexibility and in order to seek national markets for programming.[2]

Disk or Tape bicycling is the final method of establishing a local distance education network. Since it is a non-interactive (off-line) technique, it will be supplanted by other technologies once the users become sophisticated with respect to use of the materials. However, the very minimal investment in delivery technology allows resources to be placed in the Personnel and Production Departments for those institutions

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1. There are two exotic technologies which should be monitored for future last mile application with respect to ITFS. One manufacturer has announced the availability of an ITFS/DS-1 multiplexer which purportedly can carry a DS-1 signal *within* the video picture information, thereby respecting FCC bandwidth limitations. In addition, public comments are currently being received by the FCC concerning the *LMDS* (Local Multipoint Distribution Service), which would be a very high frequency version of cellular video telephone. Neither of these technologies has been thoroughly evaluated to date; however, these "clouds on the horizon" may cause some minor tweaking of the last mile options within three or four years. In any case, major impact to the overlay network is not expected.
2. This secondary role as recommended for usage of satellite technology represents a significant departure from the results of two previous reports: *The NCTC Study*, a 1981 report which recommended a six-state educational satellite interconnect, and the *Educational Satellite Use Study*, conducted by the WECB in 1988, which suggested that educators should focus on satellite usage for educational programming. The reason for the change in emphasis is the acceleration of terrestrial technologies over the intervening five to twelve years. Many of the general recommendations of these earlier studies remain valid, however, including the conclusion that Wisconsin should actively work to become a major importer and exporter of educational programming.

just beginning to become involved in distance education. In this manner, expensive light fiber or microwave delivery systems do not stand idle while the production end of the system comes up to speed.[1]

Perhaps the most important point to make with regard to the technology mix for the local networks is that *there are indeed technology choices.* It is not appropriate to assume that there is only one method of electronic transportation, nor that there is only one supplier.

Frequently, a **Hybrid Mix** of the above listed technologies is the most effective solution. For instance, where regulated fiber vendors have well established routes, low cost digital transportation is available. Alternate means such as Cable TV, unregulated carriers, or private microwave can be used to bridge the fiber "gaps."

The attached Appendix M details methods of interconnecting local video, data and voice networks to remote terminals.

6.1.1.1.2 Recommended Means of Determining Which Transportation Mix Is Most Appropriate In The Local Loop.

In general, it is not possible to determine accurate competitive prices from vendors by merely asking them questions such as, "How much does it cost to lease a dedicated DS-3 from point A to point B for five years?". The price equation depends on many factors, and in most cases insufficient information is at hand for an immediate answer. If the customer is persistent in questioning the vendor, he or she may obtain a price which will usually represent the higher limit of the possible price bracket. The reason for the difficulty in obtaining the best price is the lack of a competitive environment[2], and the fact that the responding vendor must frequently make executive level decisions regarding the installation of new terminal equipment and fiber links. It should be appreciated that the cost to these companies for a full system engineering design is not insignificant, and most of them cannot afford to undertake such an extensive and expensive effort on behalf of each potential customer casually requesting a price.

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1. This is not to minimize the potential of the tape bicycling technique. One particularly successful organization, which supplies college lectures on video tape, is the *SuperStar Teachers* Company. This company is affiliated with the Smithsonian Institution and offers a wide variety of taped courses from Nietzsche to Astronomy. These tapes can be purchased or rented.
2. One common carrier vendor contacted by this consultant asked if they would have competition for the business outlined by a particular request for quotation. When told that microwave was also an option, they offered the information that their quotation would be coming from "the competitive price list." It should be remembered that even though the Wisconsin Public Service Commission does not generally permit the rate payers to pick up the cost of new fiber, neither do they prevent the carriers from charging the cost to their investors. In addition, as the Urban Telephone case in Clintonville shows, some telephone companies *can* provide lower-cost fiber if they are willing to confront regulators and investors with creative solutions to entrenched labyrinthine costing procedures.

The solution to the conundrum represented by telecommunications feasibility design is to formulate the system design independently of the vendors, specifying requirements and capabilities rather than technologies. *All vendors*, representing all possible technologies, should then be asked to competitively bid on the facilities in a formal environment involving a *Request for Proposal*. Evaluation of the bids should include the option of selecting multiple vendors according to the most compliant carrier for each *link* of the proposed network.[1]

The best way to evaluate the cost of technologies is via an RFP sent to all vendors.

6.1.1.1.3 Summary of Recommendations for Local Networks

As previously described, the choice of technology for local networks is usually determined by cost and availability of resources. Although fiber is the best all-around choice, all of the other technologies listed above can reasonably be employed on the local level. Microwave, ITFS and cable TV can be effectively used to reduce the cost of bringing signals to the end user. It is important that local systems be created in a manner that will allow them to be connected to regional and statewide networks.

This study fully supports the idea that local systems should be allowed to make their own decisions regarding technology and local network planning, consistent with the requirement that interoperability is preserved and duplication of equipment is avoided (a state of affairs which would occur if statewide standards are observed).

6.1.1.2 Technology Recommendations For The Regional Network Element

6.1.1.2.1 Recommended Technology Choice Set

Regional networks serve to interconnect more geographically dispersed clusters of users, such as technical schools to be connected with their K-12 district, or several higher educational institutions within a CESA. The following technologies are considered appropriate for this network element (in the approximate order of preference):

Digital light fiber provided by regulated or unregulated common carriers is to be preferred if it is cost effective as previously described.[2]. This pricing method is especially of interest in the regional network because it changes the basis of new fiber installation costs to reflect only the cost of money between the incept date to the time when the fiber would be installed for other purposes.

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[1] Some vendors would argue that a subscriber/vendor partnership can be just as effective as a method for establishing the most cost- effective network, provided that a third party (such as a consultant) is present to protect the interests of the users.

[2] The PSC and the telephone industry are cooperating on a new pricing model called *Fiber Incremental Pricing*

Digital microwave transportation provided by **unregulated carriers** (such as the Wisconsin DOT or MRC) would be the next best choice if service is available, and established nodes could be linked in a single hop.

Regional networks should be a hybrid mix of fiber and microwave (including some ITFS).

Analog microwave transportation provided by *unregulated carriers* can be utilized if available in the area to reduce costs if the relatively limited capacity is not a problem, and if there is upward compatibility with future digital use.

Hybrid Mixed Technology Networks can frequently be used to good advantage at the regional level.

It should be noted that there are still some areas where a new ITFS system or an expansion of an existing system can provide effective broadcast-mode service for many years before it will become obsolete. Especially if the alternative is no service at all, ITFS can serve as a complimentary broadcast outlet at the periphery of the statewide distance education system by feeding programs into the network and accepting programs from the network. Several particular ITFS projects have been identified which, in the judgement of this consultant, should proceed if construction commences before the end of 1994:

- Additional channel for NCTC in Wausau (already proceeding).
- System expansion at FVTC in Appleton (already proceeding).
- New ITFS system in Door County (subject to obtaining a new light fiber quote).

The statewide interconnect of the existing and recommended new ITFS systems has the capability of enhancing their utility rather than unavoidably causing their immediate demise. The ability to obtain real-time access to additional programming, and the possibilities inherent in marketing telecourses, should breathe new life into these networks for the next few years until fiber migration is complete.

6.1.1.2.2 Summary of Recommendations for Regional Networks

As with the local networks, it is felt that common-carrier provided fiber is the best technology choice for the regional network. However, microwave transportation may be a good alternative if the respective disadvantages (such as limited carrying capacity compared to fiber) are not a limiting factor. As alluded to previously, microwave can be very cost effective in adding a few isolated users to a network.

Existing applications involving one-way video, ITFS, satellite, and broadcast TV should be configured so that they may be effectively connected to the overlay network to enhance program distribution.

As with the local network element, technology choices and administrative control should remain with the regional consortia. The RFP process is also applicable to the regional networks, although extensive coordination will be necessary at the state level to minimize duplication of effort and ensure adherence to overlay network standards. Such coordination is especially important for the regional networks, some of which may actually be used as interim links in the state overlay design.

6.1.1.3 Technology Recommendations For The Overlay Network Element

The recommended State Overlay Network would serve to interconnect multiple clusters of independent regional and local networks. Both digital fiber optic and digital microwave systems are recommended to be used for this network element.

6.1.1.3.1 Recommended Technology Choice Set

Existing microwave segments could be used today where fiber is not available and where channel capacity is sufficient. After a migration to a mostly-fiber overlay network, existing microwave systems could be retained to provide redundancy and route diversity for some segments of the network, as well as to service the more remote local endpoints.[1] An illustration of the final proposed statewide overlay network ("WODIE") is included in this document as Appendix A. This map is based on the locations of schools, existing regional networks, libraries, major hospitals, and existing/planned telephone company switching sites (see Appendixes C, D, G, H, I, J, K and L). It is assumed that such a network will probably take up to ten years to fully implement, with the "primary" (OC-12) routes being among the first links to be installed.[2]

For the overlay network, digital fiber and microwave are recommended.

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[1] This concept of a *travelling microwave link* can be used to good advantage. The cost to move a microwave link is relatively low, especially if antennas can be placed on existing buildings, water towers, or other supporting structures (the list of state-owned towers is tabulated in Appendix F). The TV networks have been doing this for years to provide interconnections for special events such as football games and the Olympics.

[2] Of course, the primary links may initially be installed at lower capacity, such as 2-DS-3, until traffic warrants expansion.

6.1.2 Recommended Agency Responsibilities

Although the details of the state agency inter-relationships with respect to management of the overlay network must be worked out among the personnel involved,[1] there are some general observations which fall under the mandate of the distance education study. These observations are described below.

6.1.2.1 Wisconsin Educational Communications Board

The statutory mandate of the WECB outlines the WECB's mission:

WECB's recommended responsibilities with respect to the statewide distance education system are given in this section.

The WECB should "Provide leadership in securing appropriate funding for regional educational telecommunications networks maintained by schools and other educational institutions, coordinate the development of networks and establish technical standards for the networks and their interconnections." [*Wisconsin Statutes 39.11 (20)*].

In 1990, the Wisconsin Information Technology Management Study concluded:

"While regional consortia should take the lead in initiating and managing educational video networks, the state should, through the Wisconsin Educational Communications Board, play a major role in their development by setting network technical standards, overseeing and coordinating network development, meeting technical utilization training needs, and by providing incentive funding for system initiation and planning. The WECB should be provided appropriate staff and operational resources to meet this additional responsibility." [*Information Technology Management in Wisconsin, November 1990, p. 28*].

These mandates provide the WECB with a very clear set of responsibilities with respect to the statewide distance education system:

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[1] Presumably with the assistance of the DETIC.

- Tabulate and disseminate technical standards and other information for use in the overlay network and for use by the local and regional networks. Provide ongoing training and networking opportunities for technology and applications.[1]
- Assist local consortia with funding requests, and to coordinate development of distance education technologies and programming.
- Suggest logical aggregation of proposed new networks so as to avoid duplication and effectively meet the needs of both the public and private sectors.[2]
- In cooperation with the Department of Development and the Governor's office, assist the State of Wisconsin's efforts to provide an information infrastructure which will have a positive influence on the relocation plans of business and industry. At the 1992 Council of Great Lakes Governors, the following statement on telecommunications and economic development policy was approved:

"Telecommunication's importance in economic development has increased to the point where it has joined the list of "must haves" for firms looking to locate or relocate their operations. Site planners now routinely rank access to advanced telecommunications among the top ten needs along with such factors as an available labor force and reasonable tax structures. Numerous studies ... have shown a direct correlation between infrastructure investment and economic development... For each dollar invested in telecommunications, consumers can expect *three dollars of benefit* in terms of economic resource savings [emphasis added]. Infrastructure development, therefore, can improve the economic competitiveness of the region ... while bringing the benefits of new telecommunications technologies to the consuming public."

- Assist the users and DETIC Committee members in the creation of a proper administrative structure encompassing the following areas:

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[1] The WECB "Expertise Bank" has the potential of saving local educational institutions a great deal of time and expense. For instance, many users do not know that it is possible to multiplex from two to four NTSC video signals on *one DS-3* using a *frame multiplexer*, a fact they are not likely to learn from some vendors who would rather lease additional DS-3s.

[2] The importance of this item cannot be overemphasized. For instance, each of the three DS-3 regional systems which have been installed to date have specified their own controller switch. Just *one* of these controllers has the capability to run at least *four* separate systems of similar size. As another example, nearly all distance education systems being planned at the present time wish to reach operating programs in Clintonville and Wausau. By employing a topology which allows a wider bandwidth to be used on a hub backbone, the connection cost could be significantly lower for each attachment than it would be if every institution pursued its own deal with the carriers.

- A scheduling committee to manage traffic on the overlay network
- An executive structure (either an individual or a committee) to function as day-to-day administration
- An organizational chart to establish a path for the making of network policy and priorities
- A structure to monitor and maintain network technical parameters, such as switching, routing and password access

The WECB is in an ideal position to manage these tasks, since alone among the Wisconsin state agencies it has a representative board which serves the Administration, the Legislature, the UW system, the VTAE Colleges, the private colleges, and the K-12 system.

The WECB has recently experienced a reduction in staff. With the recommended increased responsibilities, it is estimated that an additional 1.0 FTE will be required. This person should be familiar with wide area network technical and administrative issues.

Finally, the WECB should investigate funding methods for the proposed network, and should seek "pump priming" finds to encourage the formation of regional and local networks.

6.1.2.2 The Department of Administration

Since DOA, through its Bureau of Information and Technology Management, presently manages the state STS telephone system as well as the Consolidated Data Network and the Lottery Network, it would be logical that this agency act as the centralized leasing agent to acquire electronic transportation capacity for WECB clients.[1] The DOA would also write and enforce vendor contracts.

It is recommended that DOA act as the centralized leasing agent.

When the technique becomes viable, it is recommended that DOA/BITM consider dynamic assignment of bandwidth on the routes it controls. This is a management tool which requires sophisticated computer programming, but which yields maximum network efficiency and ultimately lower costs.[2] Dynamic allocation allows the network to be sized for the average load rather than the peak load, as described by Figure 6.2.

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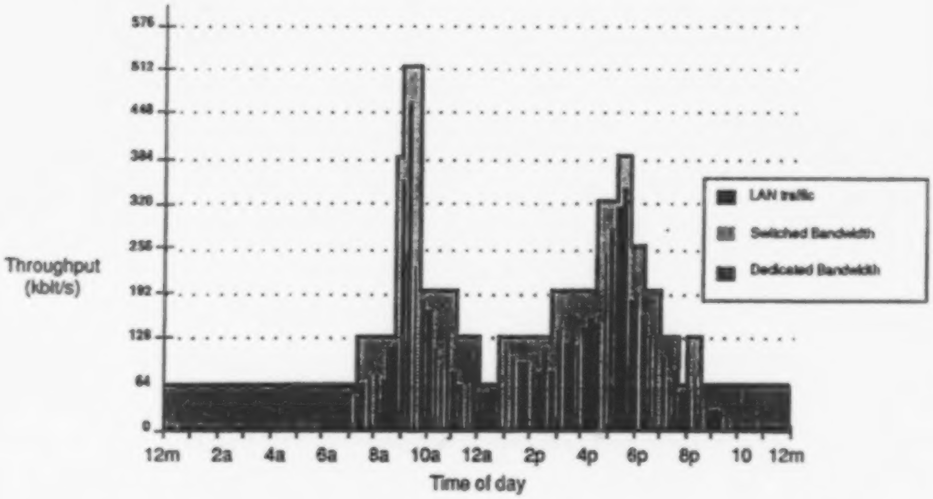
1. The term "network management" is subject to some uncertainty in definition (see the discussion under "WECB Responsibilities"). It is necessary that the WECB and the DOA work closely with each other in order to effectively carry out the expanded roles envisioned herein.
2. Toward this end, STS and CDN vendors should be encouraged to upgrade their switches to employ ATM and SONET compatibility.

LAN Internetworking Dynamic Bandwidth Allocation



- **Pay only for bandwidth when you need it**

Figure 6.2

It is expected that a minimum of one administrative and two technical FTEs would be required to perform these tasks. These persons could also assist in the periodic update of the *Statewide Information Technology Plan* (October 1992), which among other things explores the relationship between business and the Wisconsin information infrastructure.

It is recommended that DOA receive a copy of the imminent Broadcast Interconnect RFP when it is issued, so that the possibility of utilizing the current STS vendor can be investigated.

6.1.2.3 The Department of Transportation

The Division of State Patrol

The Department of Transportation is not represented directly on the WECB's board. A liaison should be established with the Division of State Patrol's Bureau of Communications so that synergies between the distance education initiative and the requirements of the statewide repeater/microwave system can be explored. Such a mutually beneficial relationship would provide for DOT/DSP:

It is recommended that ECB work closely with DOT to advance mutually-benefitial initiatives.

- Additional or new repeater site interconnect capacity.
- Video training sessions from Camp McCoy and other sites.
- The capability to defray some of the cost associated with the WICORTS Public Safety Mobile Radio Initiative (Wisconsin Interagency Committee on Radio Tower Sites).

The relationship would provide for WECB:

- Established backbone microwave routes which could be utilized during the migration phase and later for route redundancy.
- Links to regional networks.

It is recommended that DOT receive a copy of the broadcast interconnect RFP when it is issued, so that these possibilities can be fully explored.

The Division of Highways

A change of policy at the federal level has made it possible for the WisDOT to utilize a portion of the Interstate Highway System right-of-way for local fiber optic purposes. The USDOT is installing conduit for use by the "intelligent highway" of the future, which will enable a 4" conduit which would be usable by the overlay network. This possibility should be coordinated with WECB.

6.1.2.4 The Public Service Commission

The PSC is charged with the responsibility of protecting the telephone rate payer from excessive charges, while at the same time ensuring that the system providers are financially healthy enough to provide first class service. This tightrope act occasionally leads to a collision of goals, as it did in the *Urban Telephone* case in Clintonville.

It is recommended that the PSC review its rate structure and propose modifications. The goal of these modifications are simplicity of rate calculation and a lower tier of charges for educational institutions.

In many cases, the determination of proper pricing for wide-bandwidth applications is a difficult and esoteric art, understood by only a few staff members at the PSC and relatively few people employed by the vendors themselves. Reasonable people can and do disagree on the method which should be used to calculate compensatory costs. Under the existing system, the calculation of prices is an arduous affair which makes cost comparisons nearly impossible.

It is suggested that the PSC carefully review their rate structure, especially in light of administrative law changes made by Michigan, Kentucky, and Washington state. Rule modifications should be made with a view toward simplifying the calculation of rates and, to an extent which balances the rights of the ratepayer with the state's responsibility to provide educational opportunity, a separate and lower tier of charges should be established for educational use.[1]

6.1.2.5 The Department of Vocational, Technical & Adult Education

The DVTAE should determine the level of compatibility of the in-place local college technology systems with respect to the proposed overlay network. Construction of non-compatible systems should be discouraged.

VTAE should insure that its systems will be compatible.

6.1.2.6 The Department of Corrections, The Department of Health and Social Services, and other Agencies

Both the DOC and DHSS have extensive needs relating to video conferencing and training of personnel. DHSS recently received a grant from Ameritech to establish a video arraignment link from the Lincoln Hills School to Milwaukee. DOC and DHSS should study means to utilize the overlay network as part of the existing telephone system and the proposed expansion of the institutional radio systems. A list of correctional facilities in Wisconsin is included as Appendix G.

DOC and DHSS should coordinate their two-way video needs through ECB.

Future such efforts on behalf of all state agencies should be coordinated through the WECB, possibly by the DETIC, which could act as a virtual "Department of TeleCommunications".

6.1.2.7 The Department of Public Instruction

The DPI should shoulder the delicate task of obtaining the consensus of the K-12 administrations, WEAC and other teacher associations as well as the Wisconsin Association of School Boards. The input so obtained should be provided to WECB so that these viewpoints are fully represented in the ultimate creation of the network.

Several suggested actions for DPI are provided.

Tech Prep and Current Projects

The DPI should also coordinate with the WECB concerning the requirements of its major projects, such as the "Report Card Project" and the tele-library system (see Appendix H), so that the overlay network design will reflect these needs as well. Effective communication of the benefits associated with distance education will take the DPI on a major leap toward its goal of "equalizing educational opportunity throughout the State of Wisconsin."

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[1] Because the rate situation is so arcane, and the review process is expected to take some time, a procedure should be established for dealing with rate waiver requests which must be handled in the interim. The "purple cow" technique, whereby projects are reviewed on a case-by- case basis without setting a precedent, is one possibility. Another technique being investigated is "Fiber Incremental Pricing", which would reduce up front costs on some routes to the value of money in cases where utilities have future plans to introduce fiber on an identical path. The PSC is exploring many issues relating to Fiber deployment - see PSC *Telecommunications Lightwave Systems Policy* report dated August 1992.

It should be emphasized that the creation of the proposed overlay network structure is the most cost-effective way to implement educational mandates already in force in Wisconsin. For instance, the Tech-Prep initiative has as its definition the very essence of a wideband interactive communications network between geographically dispersed institutions:

[Tech-Prep is defined as] cooperation between K-12 schools, technical colleges, universities and the business community to develop integrated academic and technical curriculums which provide a coherent sequence of courses and experiences designed to provide high school graduates with a more technically oriented background leading toward the goal of successful transition from school to postsecondary technical education and/or to work." --- *Wisconsin DPI*

Furthermore, the scale of Tech-Prep implementation virtually assumes an overlay network of the scale proposed herein:

"TECHNICAL PREPARATION PROGRAMS... establish a technical preparation program in *each public high school* located in (each) school district (emphasis added)."

"The program shall consist of a sequence of courses ... designed to allow high school pupils to gain advanced standing in the VTAE district's associate degree program upon graduation from high school."

Distance Education Position Paper

On January 6, 1992, the DPI issued a position paper on distance education, which " ... defines the responsibility for public schools when instruction is provided through a distance education medium." Three provisions of this responsibility are particularly noteworthy:

"1. Distance education should never be used to replace a classroom teacher. ... All learning activities in the elementary and middle level grades should be the direct responsibility of a fully licensed teacher."

"5. A Wisconsin-licensed teacher must be assigned by the school district to be the on-site teacher for each distance education class. ..."

" ... Distance education, except advanced placement, VTAE advanced standing or dual credit courses, or approved children at risk courses or programs, may not be used to satisfy any of the basic 13 credits required for high school graduation ..."

These three provisions have resulted in some degree of confusion among local schools with respect to implementation of distance education technologies at the K-12 level, especially in view of some of the new DPI mandates regarding special education. With local budgets being continually constrained, the local districts must be certain of the costs they will be facing by implementing distance education technologies. To this end, it is suggested that the DPI white paper be continually updated and clarified. This effort will address the need for regional curriculum coordination.

6.1.2.8 The University of Wisconsin

In August of 1988, the University of Wisconsin conducted an in-depth study of the telecommunications revolution and its effects upon the University. The study was titled *Telecommunications and the University: Planning For Change*.

Among other recommendations, this study urged the establishment of administrative and academic data networks, video delivery and audiographic conferencing capabilities, and a personnel support system for these networks. The proposed support system included a *Telecommunications Coordinating Council*, which was charged with the following responsibilities:

" ... [to] review and coordinate instructional planning, and advise and oversee systemwide development and utilization of telecommunications technologies. ... [This leadership is made necessary by] the need to coordinate individual institutional technology initiatives with state government agencies, other public and private educational institutions and private sector vendors on a statewide level."

It is critical that the UW Telecommunications Planning activities seek liaison with the WECB design committees.

It is critical to the orderly development of the State Overlay Network that the UW Telecommunications Planning activities seek liaison with the WECB design committees.

6.1.2.9 The Other Local Institutions

From the smallest K-12 to the largest College, each educational establishment should make its wishes and concerns regarding distance education known to the DPI and the WECB. To the extent possible, a *central contact point* should be provided, and staffed by a person who can represent all perspectives of telecommunications including voice, computer data, video and educational graphics.

Each school should be willing to shoulder its part of the distance education load, which includes equipping electronic classrooms and maintaining them.[1] Instructional staff should be encouraged to develop programming which can provide income, and to identify programs at other institutions which can expand course offerings in a cost-effective manner. Usage on the overlay network should be estimated so that the WECB and DOA can establish a fair usage tariff. Users should also maintain contact with the WECB and other agencies to fully develop the "checklist for users" (example below):

- Form a consortium with your neighbors.
- Do an internal or external needs and resources assessment, followed by a feasibility study and cost estimate.
- Contact WECB concerning network standards and programming opportunities.
- Obtain letters of commitment from consortium users.
- Determine time scales, and create a business plan. Estimate staffing impact and training requirements.
- Market the new capabilities to local and statewide potential users.

6.1.2.10 Business and the Medical Community

With the assistance of the Department of Development, businesses and hospitals should define their training requirements, and identify university facilities, private colleges and/or vocational colleges which have established programs to which they desire access.

In addition, the extent to which such projects could be partially funded by the private sector should be determined, and the results tabulated by the WECB.

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1. Possibly making this local investment more palatable, the recently-released *The Wisconsin Plan* authored by Ameritech would provide Wisconsin with a rate freeze and central office fiber access to *every school and library in the state serviced by Wisconsin Bell* in return for certain business flexibilities. This is an awesome step on behalf of a communications vendor, and should be given all due consideration assuming that it meets the needs of the other affected Wisconsin interests.

6.1.2.11 The Telecommunications Vendors

Enthusiastic participation on the part of vendors is also critical.

The enthusiastic participation of the electronic carrier community is critical to the success of the distance education effort. The vendors represent an enormous resource in terms of both experience and expertise; to not include the carriers in network planning would be to repeat the mistakes made in Iowa. It is recommended that a direct access path be established to the WECB in order to ensure vendor participation in all major phases of network development.

In general, the IXCs and the LECs stand to gain substantial new business through expansion of their Wisconsin infrastructure as a result of distance education, especially if PSC regulations continue to be relaxed. On the other side of the coin, these vendors should present a united front to the FCC in Washington D.C. so as to obtain a favorable ruling concerning the application of federal tariffs to the feeding of broadcast and ITFS facilities in the manner envisioned by the proposed network.[1]

Each of the telecommunications transportation vendors should be willing to explore new partnerships. For instance, telco/cable TV partnerships would be especially productive. A marriage of regulated and unregulated carriers would provide the best of both worlds to vendor and user alike by lowering costs and increasing utilization of existing resources (a MRC/Access partnership would be a good example).

As mentioned previously in this document, the Cable TV vendors should seek to improve the communication channels with respect to the WECB.

6.1.3 Incorporating Existing Networks On the Overlay

6.1.3.1 The WECB TV and FM Interconnect System

The TV and FM Interconnect can be the first step in the distance education overlay network creation.

Currently, WECB uses a statewide microwave network, leased from an unregulated microwave carrier, to distribute the Wisconsin Public Radio and TV signals to the local broadcast station outlets around the state. The lease for these facilities is up for renewal in 1994. This study recommends that the existing WECB TV and FM interconnect network be folded into the proposed distance education overlay network as the first step in implementation of the statewide plan (see Appendixes E and N, attached). Following the proposed overlay routes with the broadcast interconnect will allow continuing budget funds to work toward expanded capability, such as two-way connections between the TV stations, stereo sound, and High Definition TV when it is available.

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[1] At the present time, the FCC requires that federal tariffs apply if more than 10% of the traffic on a given route is destined for a "broadcast facility". The situation is clear with respect to the state broadcast TV network, but not so clear with respect to whether or not an ITFS station is a "broadcast facility." A FCC petition for summary judgement may be required, something only the vendors can initiate. In a letter from the WECB legal counsel which references Section 396H, it would appear that the telcos *do* have the flexibility of providing favorable rates with respect to ITFS and TV interconnects.

This integration can be accomplished by preparing an RFP for the renewal of the interconnect system containing technical standards which are compatible with the proposed statewide network, and which respects the anticipated topology.

6.1.3.2 Existing ITFS Systems

Existing ITFS systems will be able to connect to the statewide network with the simple expedient of adding a codec to the node which provides the gateway. Although the ITFS users will not have access to all of the overlay network's features, the rapid transportation of programming both incoming and outgoing will vastly extend the utility of the ITFS network.

6.1.3.3 State Agency Programs

At the present time, several efforts are under way to establish video conferencing for use by state agencies. Ameritech has provided grant money to several Wisconsin agencies and institutions (such as DHSS, DOA and the Western Wisconsin Planning Group for instance).[1]

Understandably, Ameritech is providing these grants conditioned on the requirement that Wisconsin Bell facilities be used. However, there is a substantial danger that proper system planning and observance of standards may become lost in the scramble for these seed dollars. It is even possible that in some isolated cases use of these grants may not be worth their long term cost. It is recommended that the full DETIC committee and the DOA carefully consider each of these grants in the light of their implications to the network.

6.1.3.4 Existing Local and Regional Interactive Networks

Interfacing the State Overlay Network with local and regional systems employing a cornucopia of diverse technologies will be a significant challenge. Such an effort will require the full involvement of the individual institutions, the affected consortiums, the vendors, WECB, and DOA as a minimum set. The forum within which the interfacing challenges are discussed and resolved will depend on the yet-to-be-agreed-upon governance structure, but it is assumed that the WECB would coordinate these endeavors.

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[1] Ameritech has been very active in "seeding" the distance education market in the five states where they have a presence. As part of the *Superschool* project, they are providing grants in Wisconsin and Illinois, while in Ohio they have been providing free use of fiber for up to five years. Approximately once per year, Ameritech conducts a *Supercom* symposium in order to " ... demonstrate how the walls of the traditional classroom can be expanded with the communications pipelines of technology, taking children across the country and around the world." This is a laudable effort, and serves to increase the general level of awareness concerning distance education possibilities.

6.1.4 Migration Plan Summary

The detailed migration plan is presented in Appendices N and O, attached. Appendix N shows a sequence of links detailing one possible network genesis, while Appendix O shows a decision tree flow chart which describes the steps required to implement WODIE while allowing for mid course corrections based upon future technology changes and the status of the regulatory environment. It should be emphasized that the network genesis maps represent only one possible scenario out of the hundreds possible; the actual sequence will depend upon vendor responses to appropriate RFPs.

A summary of the composition of the proposed network is presented.

The ultimate composition of the *WODIE* overlay network, as it is depicted in Appendix A, is 100% light fiber for the primary routes. Over the course of the next 10 to 12 years, however, it is suggested that existing state resources be used to the fullest extent by employing in-place microwave systems as well as established light fiber where its use is presently economical. One possible migration vendor scenario is summarized below:

6.1.4.1 TV/FM Interconnect - Beginning 1994:

a. MRC Microwave
b. MRC Fiber
c. MCI Fiber
d. State Patrol (DOT) Microwave
e. LEC facilities as appropriate

6.1.4.2 Network Overlay (12 Channel Path) - Beginning 1995

a. MCI Fiber
b. MRC Fiber
c. State Patrol Microwave
d. Access Wisconsin (parts under construction)
e. AT&T

6.1.4.3 Network Overlay (6 Channel Path) - Beginning 1996

a. Access Wisconsin (GTE, Wisconsin Bell and Independent Telephone Companies)
b. MRC Fiber
c. MCI Fiber

d. State Patrol Microwave
e. MRC Microwave

6.1.4.4 Network Overlay (3 Channel Path) - Beginning 1996

a. State Patrol Microwave
b. Private Microwave
c. Access Wisconsin
d. MRC Microwave

The following Figures 6.3 through 6.8 describe one possible evolution path for the WODIE overlay network. Of course, this plan is preliminary only, and subject to substantial changes once a detailed design is under way.

6.1.5 Technical Implementation Timeline

The detailed approximate project timeline is presented in Appendix N. The project would begin in 1993 and conclude approximately in 2005, although new endpoints and enhanced capacity would continue to be added to the network subsequent to that date.

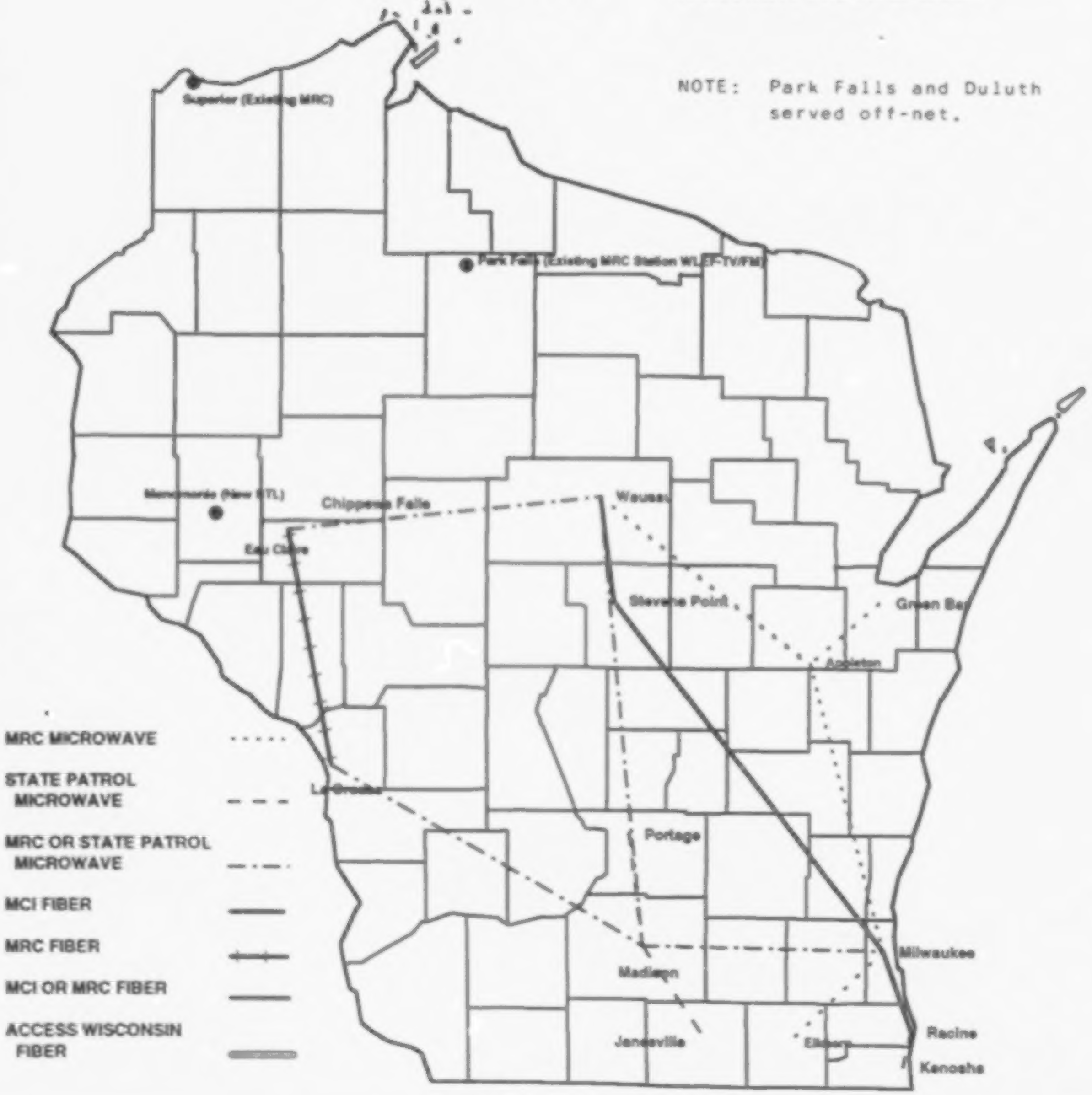
Implementation of the statewide overlay network and its regional interconnection nodes should be made using the following schedule and resources:

- 1993: Prepare and disseminate TV/FM Broadcast RFP.
- 1994: Begin creation of the network by awarding a contract for the TV/FM interconnect which is compatible with the overlay standards and routes. Work with existing and potential consortiums to add network nodes and ensure technical compatibility.
- 1995: Incorporate public and private state resources into the network, such as the Department of Transportation microwave system and the existing unregulated microwave network infrastructure.
- 1996: Begin connecting VTAE regional systems and UW systems together. Incorporate compressed video and high-speed computer networks into the system. Establish new WiscNet nodes.
- 1997: Begin last mile connection of K-12 schools and state agency traffic.
- 1998: Begin connection of libraries and hospitals.
- 1999: Begin connection of business partners.
- 2000 to 2005: Complete basic network infrastructure.

FIGURE 6.3

This map displays the television network interconnections necessary and the initial phase of the migration plan for the fiber optic network. Initially, interconnections will be made using existing microwave and fiber links.

1994/1995

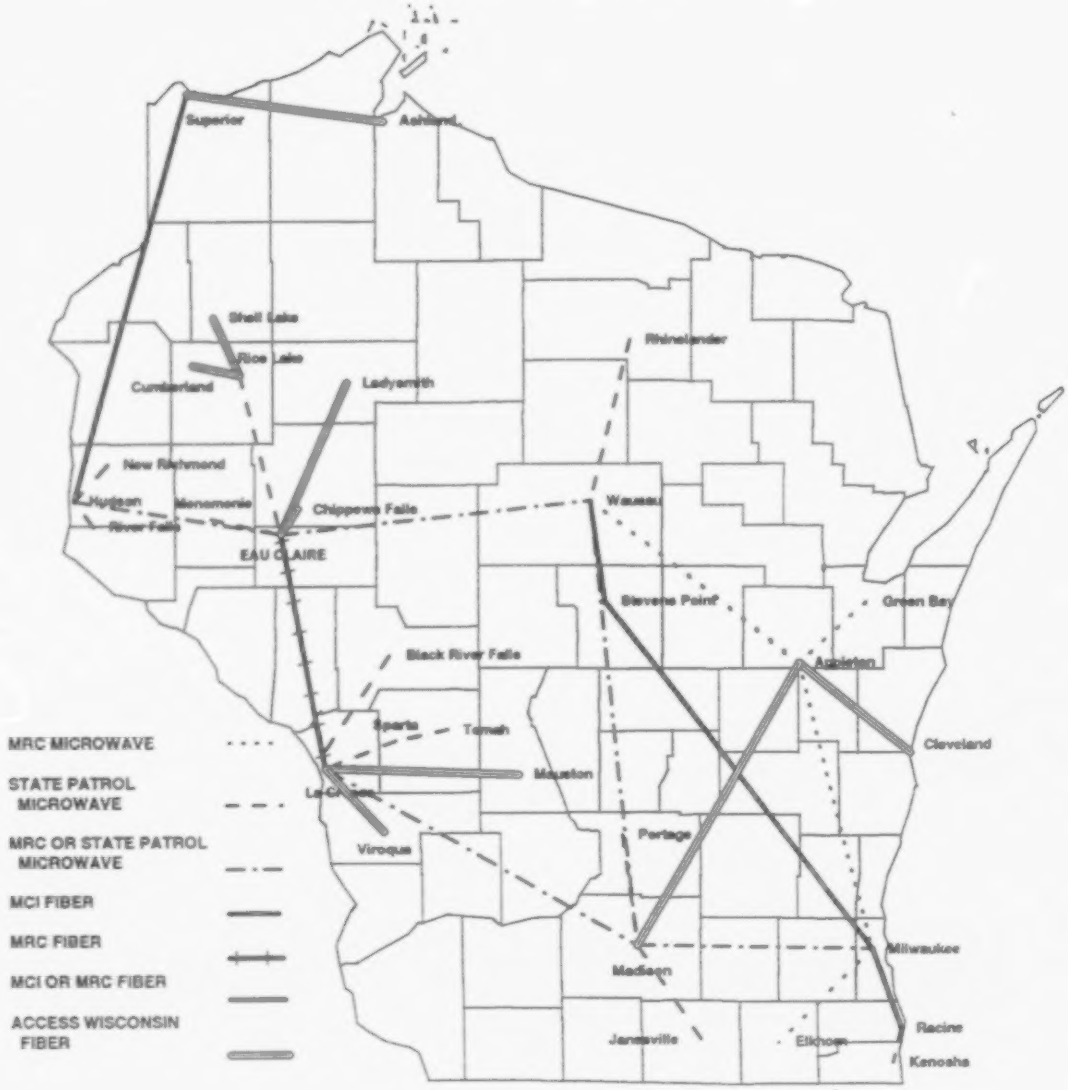

Superior (Existing MRC)
Park Falls (Existing MRC Station WLEF-TV/FM)
Menomonie (New STL)
Chippewa Falls
Eau Claire
Wausau
Stevens Point
Green Bay
Appleton
La Crosse
Portage
Madison
Milwaukee
Janesville
Elkhorn
Racine
Kenosha
MRC MICROWAVE
STATE PATROL MICROWAVE
MRC OR STATE PATROL MICROWAVE
MCI FIBER
MRC FIBER
MCI OR MRC FIBER
ACCESS WISCONSIN FIBER

NOTE: Park Falls and Duluth served off-net.

FIGURE 6.4

This map displays the second phase of the migration plan for the fiber optic network. Whenever possible, existing microwave and fiber links will be utilized to reduce start up costs.

1996/1997


Superior
Ashland
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Rice Lake
Cumberland
Ladysmith
Rhinelander
New Richmond
Hudson
Menomonie
River Falls
Chippewa Falls
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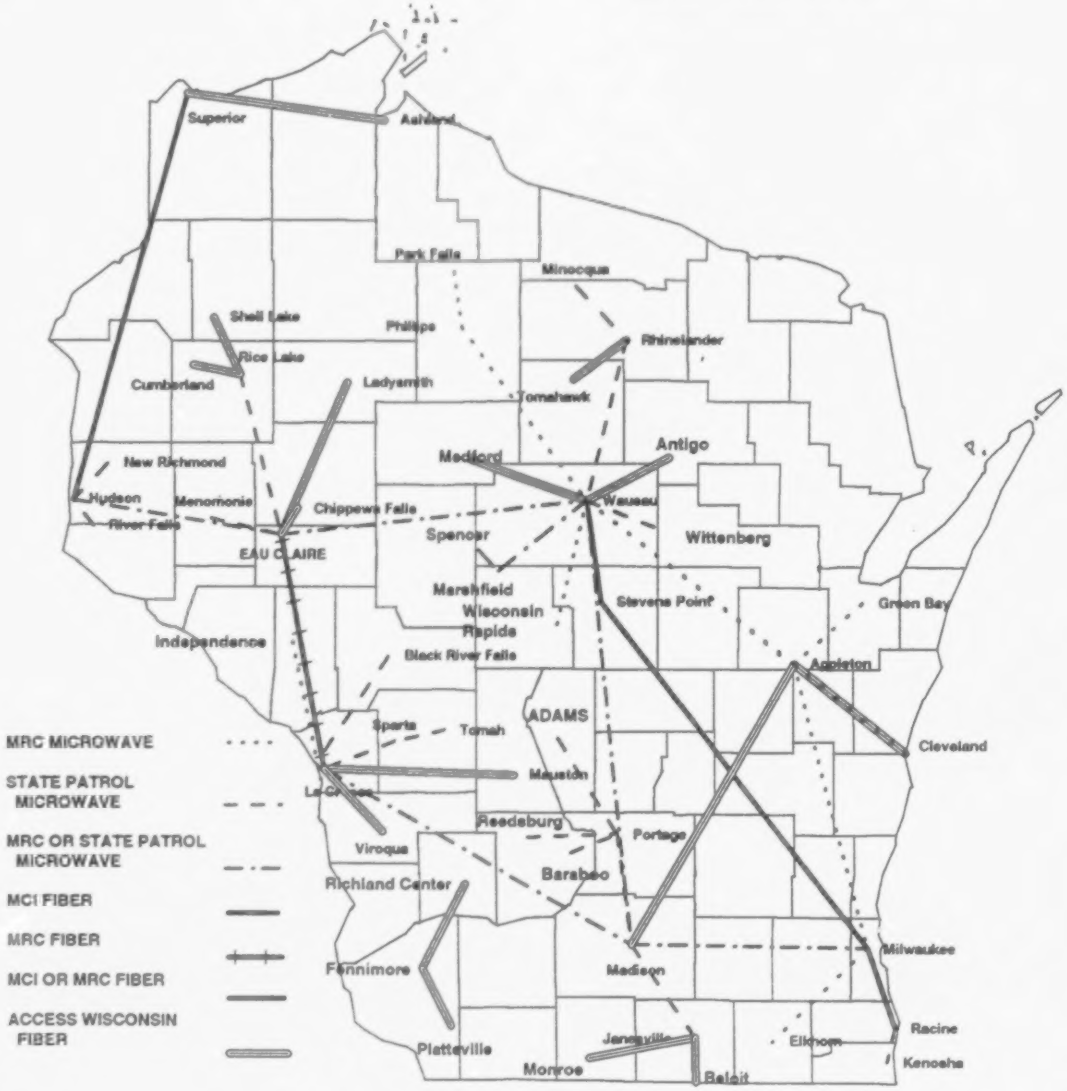
Wausau
Stevens Point
Green Bay
Appleton
Black River Falls
Sparta
Tomah
Mauston
La Crosse
Viroqua
Cleveland
Portage
Madison
Milwaukee
Janesville
Elkhorn
Racine
Kenosha
MRC MICROWAVE
STATE PATROL MICROWAVE
MRC OR STATE PATROL MICROWAVE
MCI FIBER
MRC FIBER
MCI OR MRC FIBER
ACCESS WISCONSIN FIBER

FIGURE 6.5

1998/1999

This map displays the third phase of the migration plan for the fiber optic network. Whenever possible, existing microwave and fiber links will be utilized to reduce start up costs. Notice that several of the paths will initially use fiber links for interconnection.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Minocqua
Shell Lake
Phillips
Rhinelander
Rice Lake
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Medford
New Richmond
Hudson
Menomonie
Wausau
River Falls
Chippewa Falls
Spencer
Wittenberg
EAU CLAIRE
Marshfield
Stevens Point
Green Bay
Wisconsin
Rapids
Independence
Black River Falls
Appleton
ADAMS
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Beloit
MRC MICROWAVE
STATE PATROL MICROWAVE
MRC OR STATE PATROL MICROWAVE
MCI FIBER
MRC FIBER
MCI OR MRC FIBER
ACCESS WISCONSIN FIBER

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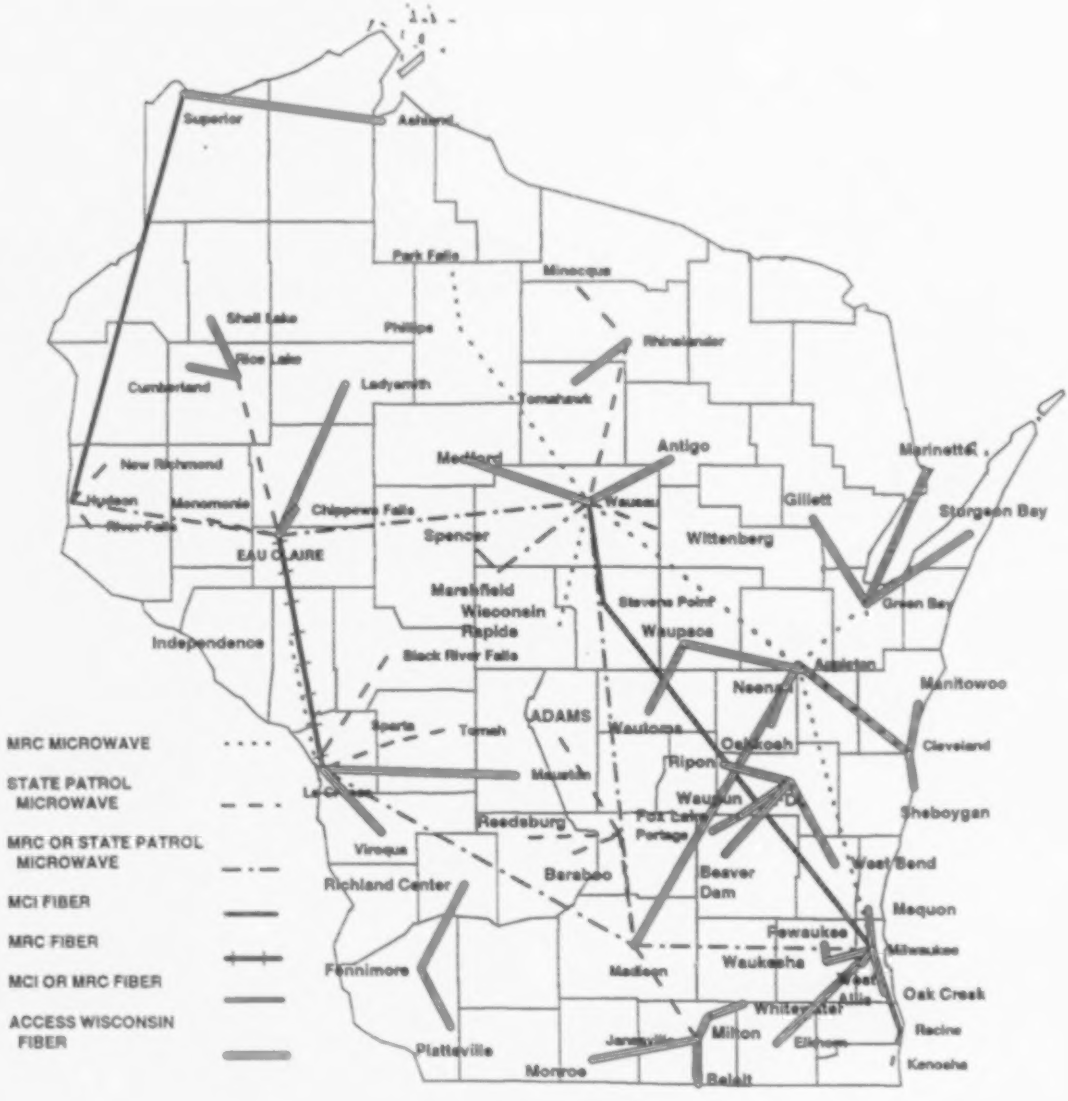
FIGURE 6.6

This map displays the fourth phase of the migration plan for the fiber optic network. Interconnections originally made with microwave are being converted to fiber optic cable.

2000/2001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Marinette
New Richmond
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River Falls
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Gillett
Sturgeon Bay
Spencer
Wittenberg
EAU CLAIRE
Green Bay
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Wisconsin Rapids
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Waupaca
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Black River Falls
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Sparta
Tomah
Wautoma
Oshkosh
Cleveland
Mauston
Ripon
La Crosse
Waupun
FDL
Sheboygan
Reedsburg
Fox Lake
Portage
Viroqua
West Bend
Baraboo
Beaver Dam
Richland Center
Mequon
Pewaukee
Milwaukee
Fennimore
Madison
Waukesha
West Allis
Oak Creek
Whitewater
Janesville
Milton
Elkhorn
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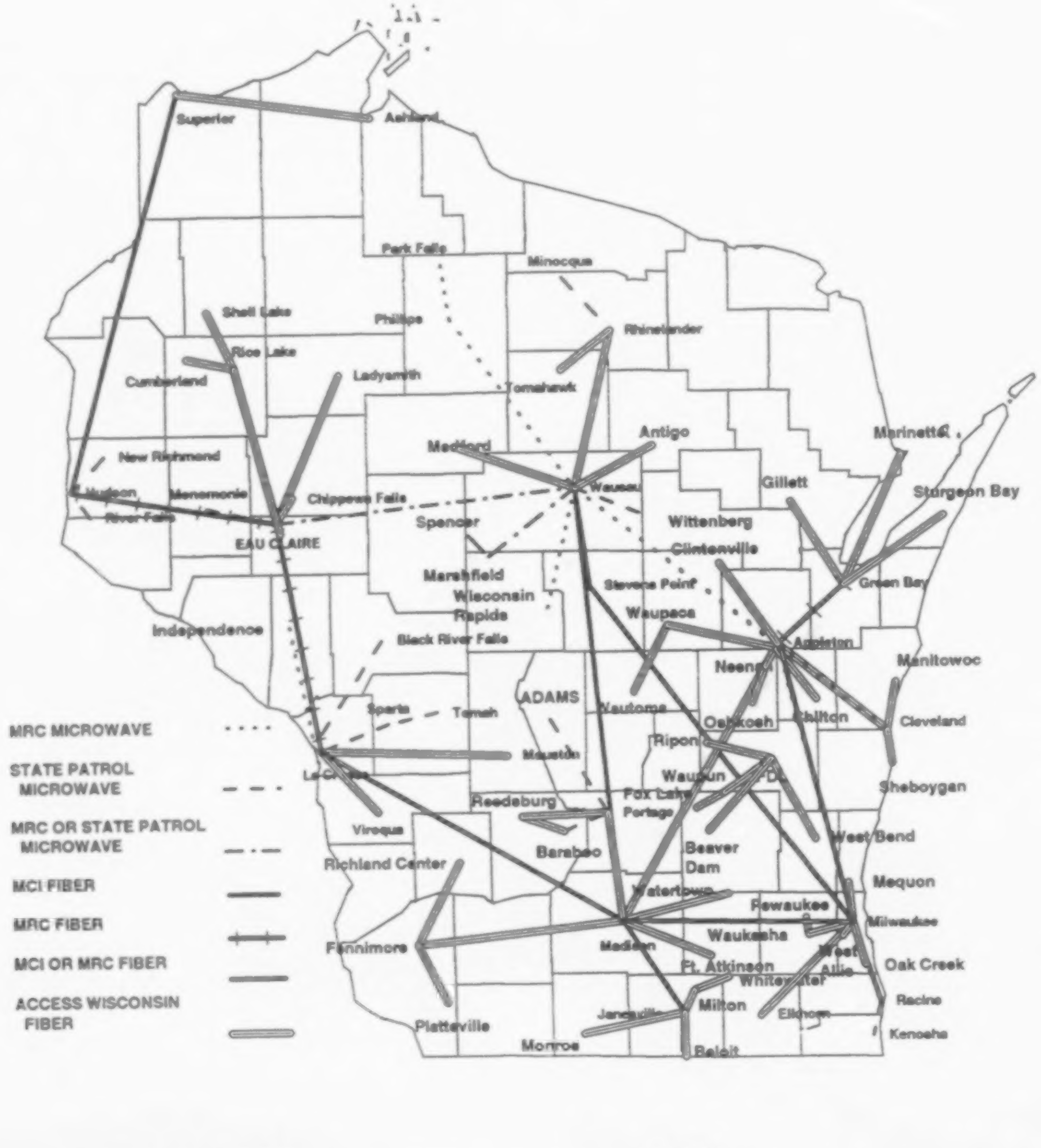
Platteville
Kenosha
Monroe
Beloit
MRC MICROWAVE
STATE PATROL MICROWAVE
MRC OR STATE PATROL MICROWAVE
MCI FIBER
MRC FIBER
MCI OR MRC FIBER
ACCESS WISCONSIN FIBER

This map displays the fifth phase of the migration plan for the fiber optic network. Notice that more interconnections originally made with microwave are being converted to fiber optic cable.

FIGURE 6.7

2002/2003


Superior
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Park Falls
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Shell Lake
Phillips
Rhinelander
Rice Lake
Cumberland
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Marinette
New Richmond
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Chippewa Falls
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Spencer
Wittenberg
Clintonville
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Wisconsin Rapids
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Sheboygan
Reedsburg
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Beaver Dam
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Pewaukee
Milwaukee
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Madison
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Ft. Atkinson
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MRC MICROWAVE
STATE PATROL MICROWAVE
MRC OR STATE PATROL MICROWAVE
MCI FIBER
MRC FIBER
MCI OR MRC FIBER
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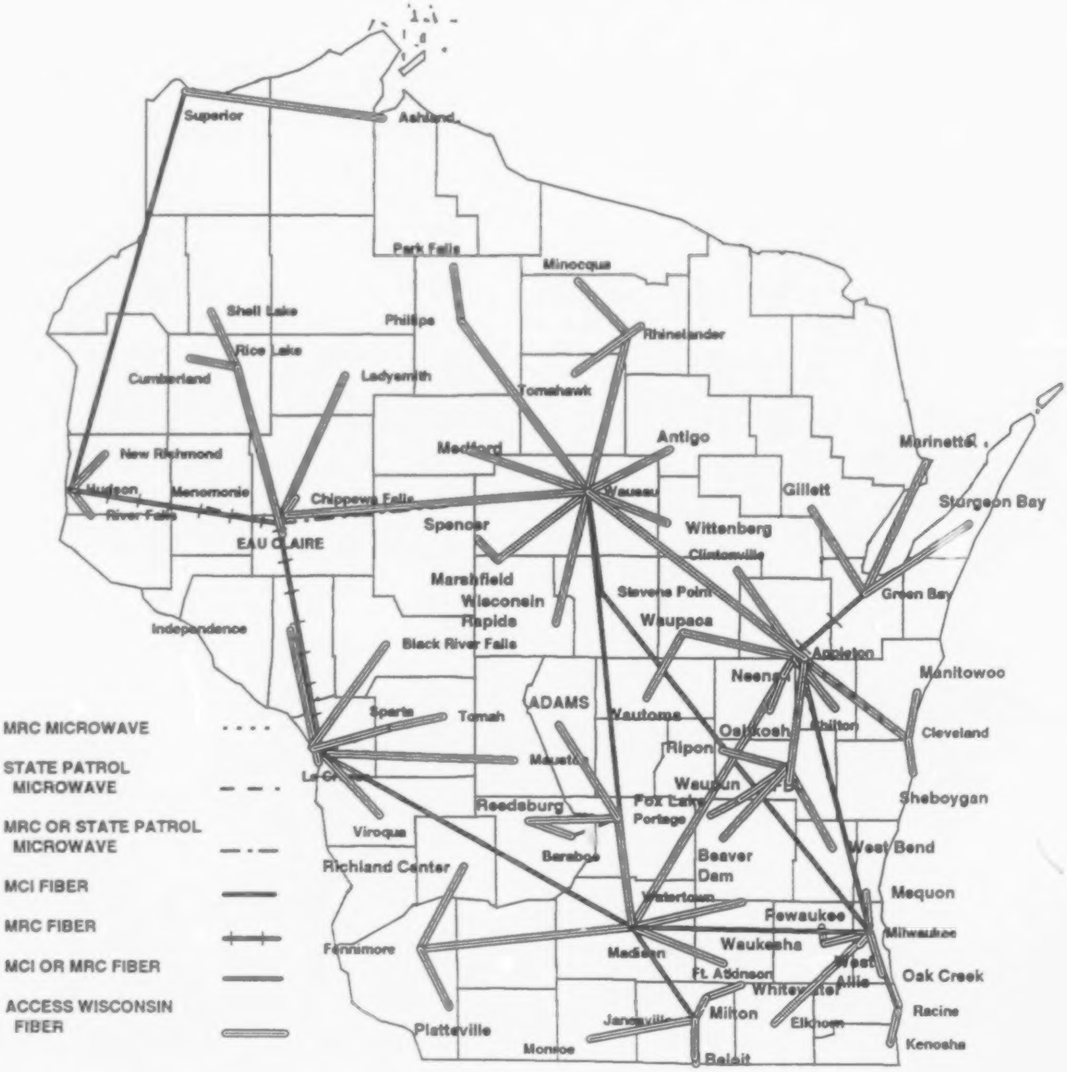
FIGURE 6.8

This map displays the sixth and final phase of the migration plan for the fiber optic network. All interconnections will be made with or converted to fiber optic links.

2004/2005


Superior
Ashland
Park Falls
Minocqua
Shell Lake
Phillips
Rhinelander
Rice Lake
Cumberland
Ladysmith
Tomahawk
Antigo
Medford
Marinette
New Richmond
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Sturgeon Bay
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Spencer
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Wisconsin Rapids
Stevens Point
Green Bay
Waupaca
Independence
Black River Falls
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Sparta
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Fox Lake
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Sheboygan
Viroqua
Baraboo
West Bend
Beaver Dam
Richland Center
Mequon
Watertown
Pewaukee
Milwaukee
Fennimore
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MRC OR STATE PATROL MICROWAVE
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MRC FIBER
MCI OR MRC FIBER
ACCESS WISCONSIN FIBER

6.2 Procedural Implementation Timeline

The following schedule is recommended for the implementation of administrative procedures as outlined in this document:

This section gives actions to be performed in each year of the proposed network creation.

6.2.1 1993 - Begin Coordination Of Technical Standards and Identification of Funding Sources

WECB should be established as the clearinghouse for local and regional system standards and vendor lease terms as soon as is practical. At the same time, WECB should seek funding from appropriate public and private sources to seed the local distance education environment. WECB should consider setting up a computer bulletin board or audiographics teleconference capability at the TOC to aid in the dissemination of information.

A summary of recommendations for the state is presented.

As mentioned earlier under Section 6.1.4.1 (WECB Responsibilities), it is recommended that the state concentrate its efforts on the creation of the overlay network while allowing local/regional groups to construct the local networks. However, it is *critically important* that the state take the initiative in developing, adopting, and disseminating a set of comprehensive technical standards to which all local and regional networks must conform. Only by taking this step can the connectability of the local networks be assured. Also, such standards will insure that local users do not purchase either substandard facilities or duplicate the efforts of others[1]. For this same reason, networks designed by vendors must be discouraged.

6.2.2 1993 - Establish the *Central Clearinghouse*

Establishing the centralized leasing mechanism will take some time, perhaps as long as 18 months. In the meantime, many regional networks (such as the Fox Valley Technical College, the Madison Area Technical College, the UW System, the Western Wisconsin Technical College and the Western Wisconsin Planning Group [WONDER]) are on the brink of signing contracts with vendors for networks which have been largely planned, designed, and funded. Until centralized leasing is in place, it is recommended that a *Clearinghouse* be established within the WECB, so that the establishment of new networks can proceed in an orderly manner which will be compatible with the statewide network.

---

[1] The *Needs Assessment* revealed that the majority of regional consortiums were interested in reaching many of the same endpoints. Left to their own devices, the same network links would be invented many times over, with a net disadvantage to the average taxpayer.

6.2.3 1994 - Begin Centralized Leasing

WECB and DOA should establish the centralized leasing of high capacity facilities and establish a governance structure for the overlay network.

The State Telephone System (STS) is an excellent example of how the buying power of the state can be used to provide local users with excellent telecommunications facilities at the best possible price. STS is managed by DOA/BITM under contract with AT&T. At the present time, only fractional DS-1 circuits are available under the DOA/AT&T domain. It is this consultant's recommendation that the state expand this capability to include high capacity (up to multiple DS-3) leasing for use in regional voice/video/data networks. Where possible, both DS-1 and DS-3 circuits should ultimately be available on both a switched and a dedicated basis, so that maximum use can be made of the bandwidth.[1] The State of Wisconsin, through DOA, should also establish terms and costs for these services. The following guidelines are recommended:

- Unless the tail circuits are prohibitively expensive, the connection costs should be borne "up-front" by the state and recovered in usage charges.
- Usage charges for fractional DS-1, DS-1 (or primary rate ISDN), fractional DS-3, DS-3 and multiple DS-3s should be established for both on-net and off-net connections. These rates should be as low as possible consistent with cost recovery within two bienniums at most.

If centralized leasing is not established, local users will continue to sign long leases for fiber networks at relatively high prices. In addition, the STS network will eventually lose business as some local networks move their voice traffic to their local and regional interconnect systems.[2] By no longer paying for STS lines, local users thus save money; however, this could result in higher rates for the remaining STS customers.

6.2.4 1994 - Establish the State Level Expertise Bank

The *Needs Assessment* clearly showed that many local users require certain types of assistance with respect to distance education technology choices. It is a conclusion of this study that the State of

---

[1] One of the primary driving forces behind increased bandwidth is expected to be WiscNet/InterNet connections, as well as ETN audio teleconferences for audiographics. The DOA is currently leaning toward a pricing structure which would involve no connection fee and no monthly recurring fee, but would establish a rate of $10/hr for a 112 Kbs circuit and $30/hr for 1/4DS-1 ($75/hr off-net).

[2] State agencies and the UW System are *required* to use the STS system, unlike the VTAEs and local city governments. There is consequently some uncertainty as to the actual degree of STS hemorrhaging which would occur. In the view of this consultant, however, it would be difficult to maintain the voice traffic for the UW system, for instance, if the proposed inter-campus interconnect could off-load a high percentage of the intra-state calls.

Wisconsin, through the Educational Communications Board, provide these services, consisting of the following minimum set:

- Dissemination of general distance education information to local institutions and regional consortiums to aid them in understanding distance education technologies. This assistance could take the following forms:
    - A telephone helpline
    - Written documents and newsletters
    - Videotapes and ultimately video programming on the network
    - Frequent meetings with consortia administrators, media advisors, and narrowcast assistants
    - An electronic bulletin board
- Assistance in locating and applying for grant funds.
- Specific technology assistance with respect to telecommunications networks, including:
    - System feasibility studies and cost estimates
    - Network conceptual design and integration with other systems
    - Assistance with RFP generation
    - RFP response evaluation and contract negotiation
    - System construction supervision and proofs of performance
- Continuing assistance in obtaining facilities at the best possible price (see "Centralized Leasing" Section 6.2.3 above).

6.2.5 1995 - Update WECB Network Connection to support *Inverse Multiplexing* and Wideband Services

WECB's network connection (beginning with the previously described bulletin board) should be upgraded to an INVERSE MULTIPLEXED digital network. This network would use one or more dial-up or dedicated lines, perhaps supplied by CDN, to establish fractional DS-1 capability on a temporary basis. This could become a low-cost interim bridge to a full-scale system, which would allow local institutions to become accustomed to the administrative and personnel issues associated with distance education. Figure 6.9 shows the schematic workings of the inverse multiplexer.

6.3 Issues and Dependencies

The creation of the network envisioned in this document is dependent on the resolution of the following issues which were identified by the study:

- Because many of the local and regional consortia are poised at the cusp of implementing distance education technologies, it becomes important to establish a migration plan which

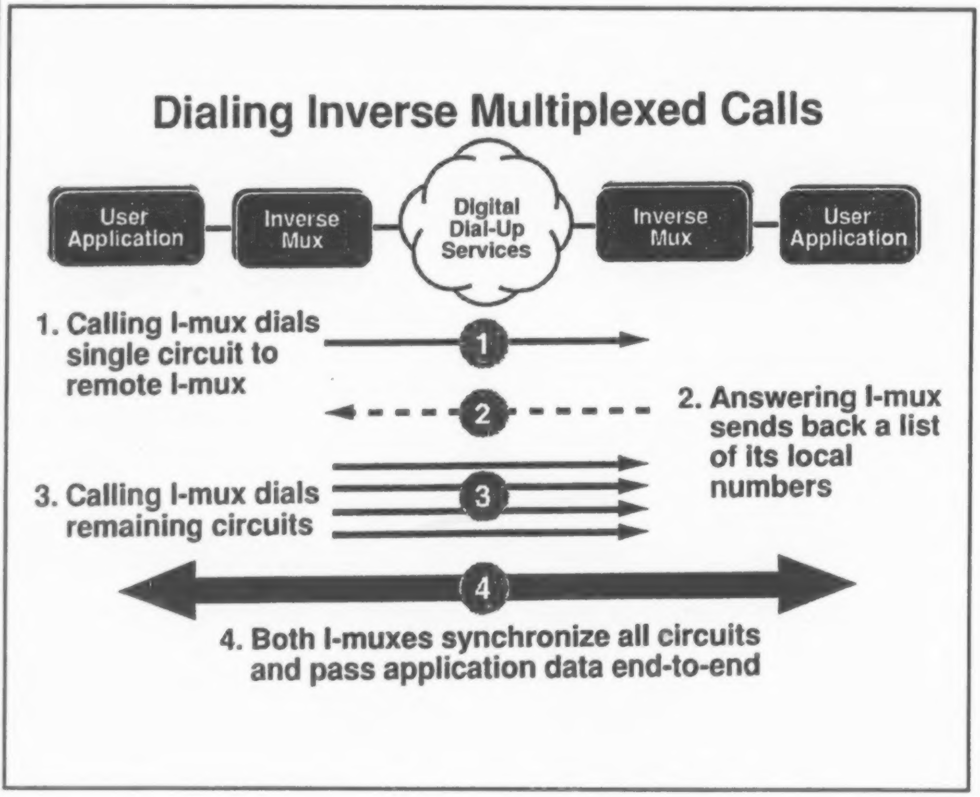
Dialing Inverse Multiplexed Calls
User Application
Inverse Mux
Digital Dial-Up Services
Inverse Mux
User Application
1. Calling I-mux dials single circuit to remote I-mux
2. Answering I-mux sends back a list of its local numbers
3. Calling I-mux dials remaining circuits
4. Both I-muxes synchronize all circuits and pass application data end-to-end
1
2
3
4

Figure 6.9

deals with the issue, "What do I do now?". This dilemma must be faced and resolved immediately in order to protect many of the primary service routes from being usurped by non-integrated networks.

In order to implement the recommendations, these issues will need to be addressed.

- The full commitment of the State of Wisconsin and the affected agencies must be obtained, starting with the Governor's office and the Legislature.
- The support of other interested groups and users must be obtained, such as teachers' unions and the school board associations.
- The business community should be approached so that estimates can be made concerning possible income from partnerships.
- The maximum degree of participation by all possible affected users must be obtained, so that the full economies of scale may be realized. Some of the largest of the potential users are entertaining the creation of wide-area networks to serve their own narrow interests; such by-pass should be vigorously discouraged.

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- The requirement that local educational institutions and consortia establish a distance education coordinator who can direct local initiatives.
- The wideband rate structure used by the PSC for telecommunications service by regulated vendors should be periodically reviewed so as not to hamper fiber system deployment for educational purposes.
- A financing method for creation of the overlay network should be determined, and an accurate assessment of the possible income obtainable from the network should be made.
- Every effort should be made to utilize state resources to the maximum extent. This means obtaining the approval of agencies such as the DOT to utilize their facilities where it is appropriate, and establishing a network of persons knowledgeable about distance education systems and technologies which will allow a free and bidirectional information flow from the highest state level to the individual instructor in the field.
- A proper administrative body must be established to oversee the network, and which fairly represents the disparate interests of distance education.

6.4 Benefits And Risks Of the Proposed Statewide Initiative

6.4.1 Conformance with the Statewide IT Strategic Plan

The recommendations proposed herein are in harmony with the Distance Education Goals stated in the Wisconsin Strategic Planning Project (WiSPP) managed by the DOA. The WiSPP plan and the WODIE plan mutually reinforce the following study assumptions:

- The state should be an enabler rather than a prescriber of the use of distance education technologies.
- The state should establish a set of technical standards, based on accepted industry standards, to ensure all distance education systems within the state can be interconnected.
- State supported distance education systems should be shared by all educational institutions within their reach, and should accommodate state agency and general community educational uses to whatever extent possible and practical.

These assumptions and the instant study conclusions support the WECB/DOA vision of a statewide interconnected distance education network which will allow every resident of the State of Wisconsin to have equal access to K-12, post secondary, and continuing adult education.

6.4.2 Advantages for Wisconsin Citizens

If the technologies, methods, standards and roles outlined above are followed, the result will be a statewide information highway which will meet all of the needs identified in Chapter 1 of this document. The telecommunications highway thereby established will not only facilitate voice, video and data communications between points in the state but will also establish access to resources available nationally and internationally.

Implementation of these recommendations will result in considerable benefit to the citizens of Wisconsin.

Creation of a statewide network will allow most Wisconsin citizens the opportunity to take advantage of educational and training resources from many diverse sources. Use of an extended teleconferencing ability will also reduce travel costs and will allow for more employee training than is currently possible.

In the view of this consultant, however, the most important advantage to be gained is the enhanced potential for *all* school districts, regardless of financial ability, to establish the fertile field required for intellects to grow. History provides us with unambiguous examples of the amplification of people resources which occurs in enriched educational environments.[1]

The ability of each student to "tune in the world" must eventually reach a critical mass involving not only formal educational systems, but all manner of occasional and non-traditional scholars cross-connected to form a light-fiber catalyzed "superconsciousness". This ability to cross-fertilize ideas will undoubtedly result in a Wisconsin "sum" (the Wisconsin workforce) which is greater than its "parts" (the individual workers), and which will improve the skills of all citizens both at home and in the workplace.[2] Just as Calvin's[3] first-grade teacher does not understand his creative approach to learning, the students in Wisconsin schools may have primary learning channels which are visual, auditory, or even tactile.

---

[1] The milieu extant in 1760 Salzburg gave the world Mozart, while one small Lutheran High School in pre-1939 Budapest simultaneously produced five Nobel prize winners, including the incomparable John von Neumann. Although both Mozart and von Neumann benefitted from educational systems which were mostly aristocratic in their acceptance procedures (or at least plutocratic), today's distance education technology promises to provide a cafeteria-style array of opportunities in a manner which is more in tune with America's egalitarian tradition.

[2] It is ironic that the most notorious dialogue disintegrator of the late 20th century, the TV set, would be an important element in finally re-establishing leisure time interactive discussion groups such as used to be relatively prevalent prior to 1950.

[3] Copyright Watterson Universal Press Syndicate.

These channels may match the techniques of the classroom teacher, but distance education can offer alternatives if they do not.

An early start toward this goal will ensure Wisconsin's place as a state friendly to business, and friendly to the mind. Another not so minor benefit of distance education is the ability to "narrowcast" to students with different learning styles.

The only credible risk associated with establishing the proposed network would be that the citizens of the state would not be prepared to use it to best advantage once it is available. In the opinion of this consultant, this risk can be managed by monitoring network utilization and adjusting the building schedule in a corresponding manner. Compared to the risks of NOT establishing the network, including higher costs to taxpayers, the possible loss of some state businesses, and the wasting of the minds of a generation, this risk is deemed negligible.

6.5 The Next Steps

After the conclusion of this study, and in concert with the previously tabulated timeline, it is recommended that the following steps be taken under DETIC direction in pursuit of the overall migration strategy outlined earlier:

In this section, suggestions as to ECB's next steps after completion of this study are given.

- Obtain continuing outside consultant support for detailed overlay network design and to assist in the evaluation of contracts for local and regional systems. Assistance should also be given to regional consortiums desiring to insert educational service clauses in cable franchise renewal contracts.
- Conduct vendor demonstrations so that terminal equipment may be evaluated, and potential users may become familiar with features and operational differences. These demonstrations could take the form of pilot projects or symposiums (such as a codec "shoot-out").
- Continue to enlist support for the overlay network, and tabulate a list of schools, businesses, and hospitals which have programming available or wish to access programming established by others. Obtain letters of intent, if possible.
- Integrate uses by Wisconsin government agencies, and local communities.[1]

---

[1] Wisconsin does not have a *Department of Telecommunications* as do other states which face the problem of coordinating government agency interconnections. Perhaps a *virtual* Telecommunications Department can be created via the DETIC committee to perform the required coordinating functions (the WICORTS committee members would be a good starting point).

- Determine the level of financial support available from the state, along with possible financing methods. Identify funding sources and assist in grant applications. If seed money becomes available, establish a "funding only after planning" philosophy.
- Determine the staffing impact to WECB, DOA and other state agencies with respect to the "clearinghouse" and "centralized leasing" recommendations made in this document.
- Continue to update the "checklist for users."
- Establish WECB as the clearinghouse for dissemination of network standards and vendor liaison. In both cases, materials provided by this study should serve as starting points for WECB's adoption of technical standards as well as standard vendor contract terms. WECB should monitor the traffic on the existing regional networks in order to more accurately estimate future overlay traffic.
- Continue to provide outreach opportunities for existing and potential user groups to share ideas with each other and with appropriate state agencies. Where feasible, establish an educational link to the business community. Establish a network administrative governance plan by obtaining an agreement in principle among all affected parties.
- Continue to assist the broadcast and narrowcast networks in the development of programming materials and in the acquisition of pertinent telecast programs.
- Assist in the creation of a plan for establishing business partnerships.
- Pursue required changes in the PSC and FCC regulations to assist in the creation of affordable fiber distance education networks.
- Maintain liaison with vendors so that RFPs reflect the reality of the infrastructure.
- Maintain and update the databases which are obtained as a deliverable of this study.

The proposed investment in distance education represents an opportunity for the State of Wisconsin to implement educational equality in an incremental way which is non-threatening to the establishment. Technology changes, whether evolutionary or revolutionary, nevertheless require a shift in attitudes, operational models, and administration. This study has concluded that the most valuable resource available in Wisconsin is *people*, and every effort should be made to incubate creative energy and use it to fire the imagination of all Wisconsin citizens.

The study has also made clear that a substantial state-level investment in time, energy and money will be required to "prime the pump" of distance education. Without this investment, the major benefits of wide-bandwidth telecommunications will not be realized for at least 15 years, and even then universal access is not assured.

As part of the continuing consensus-building effort, team building intergroup activities are suggested, representing all pertinent state entities. Top management should be brought together to discuss visions, conflicts and goals. The desired result of these meetings would be the development of plans for constructive changes with respect to the way agencies interact for telecommunications purposes.

Whatever person or administrative committee emerges from the consensus-building process should develop a plan to deal with users or administrators who are resistant to the changes proposed. Many good ideas are never implemented because managers failed to anticipate this resistance. No matter how impressive the performance characteristics of an innovation such as distance education, its implementation will conflict with some interests and jeopardize some alliances. Typical barriers to change include some of the following elements:

- Common Barriers to Change on an Organizational Level:
  - Excessive focus on the cost side of the ledger, especially start-up costs
  - Failure to perceive benefits and projected usage of systems
  - Amplification of risk factors
  - Lack of coordination and cooperation
- Common Barriers to Change on a Personal Level:
  - Uncertainty over job descriptions or qualifications
  - Fear of loss of control, power and/or status
- Example Methods for Implementing Change Given these Barriers:
  - Verify that a given change is indeed necessary, and that the desired goal cannot be achieved in a non-disruptive manner
  - If a change is necessary, find an idea which fits the need in order to begin discussion and compromise
  - Obtain top management support
  - Plan to overcome resistance by aligning change plans with the needs and goals of affected personnel, communicating with all concerned, and conducting an education program
  - Involve the maximum number of people in the decision process
  - Create change teams
  - Utilize idea champions

Early and extensive participation by everyone who is interested in distance education should be part of the implementation plan. Active participation will give all those involved a sense of control over the change. All participants will understand the change better, and will hopefully become committed to the successful implementation of statewide distance education. Figure 6.10 graphically depicts the relative investment in energy and dollars which is required in order to realize the long-term savings resulting from a major paradigm shift such as is proposed herein.

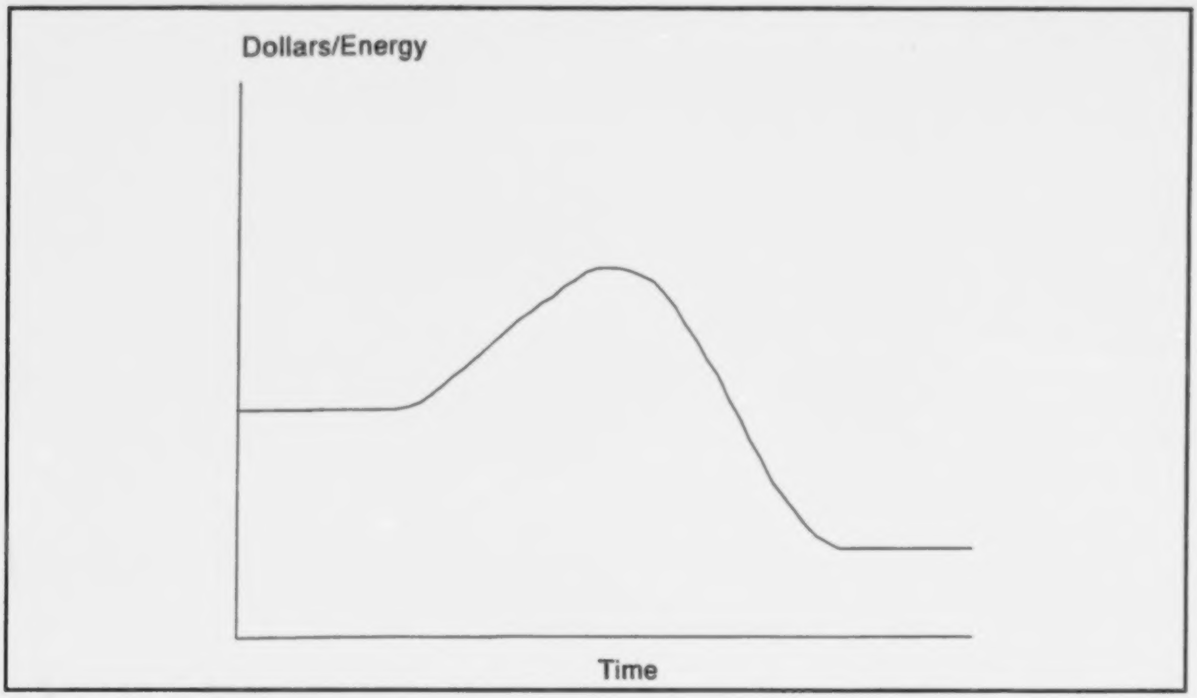

Figure 6.10 - Paradigm Curve

Many of the suggested structural changes in this document are offered in the spirit of provoking discussion, dissention, and an exchange of ideas. There are certainly many other avenues open in the pursuit of distance education which may work as well as those suggested, as long as a clear action plan is formulated.

Nevertheless, it is the opinion of this consultant that a network constructed in conformance with the specifications outlined in this study will provide all Wisconsin users with state-of-the-art telecommunications well into the 21st Century.

6.6 Disclaimer

This document has been submitted to the WECB in accordance with the requirements as stated in RFP 92-01. No usage is authorized other than as provided for by WECB.

The engineers and consulting staff of Evans Associates hereby collectively state that the conclusions and opinions stated herein represent our best good faith estimates and evaluations, consistent with our status as experts in distance education technology and procedures. It is believed that this study has served to raise the awareness level of distance education issues among educational institutions and state agencies alike.

The conclusions and statements contained in this document have not been unduly influenced so as to benefit any individual, institution, business or agency.

It should be emphasized that the statements made in this document represent an environment existing at an instant in time. For instance, many institutions have already increased their estimates of required telecommunications capacity from the figures given in the *Needs Assessment*. This study has taken nearly two years to complete, and necessarily reflects some inconsistencies due to the changes which have occurred in that time.

One benefit of this study has been the resulting increased awareness of distance education issues.

This study represents a snapshot in time, and we recognize that many factors are in a state of continuous change.

Respectfully Submitted,

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G. WISCONSIN CORRECTIONAL FACILITIES

H. LIBRARY DISTRICTS

I. VTAE LOCATIONS

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M. NETWORK CONNECTION DIAGRAMS

N. MIGRATION PLAN

O. NETWORK DECISION TREES

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R. STANDARDS DOCUMENT

S. GLOSSARY

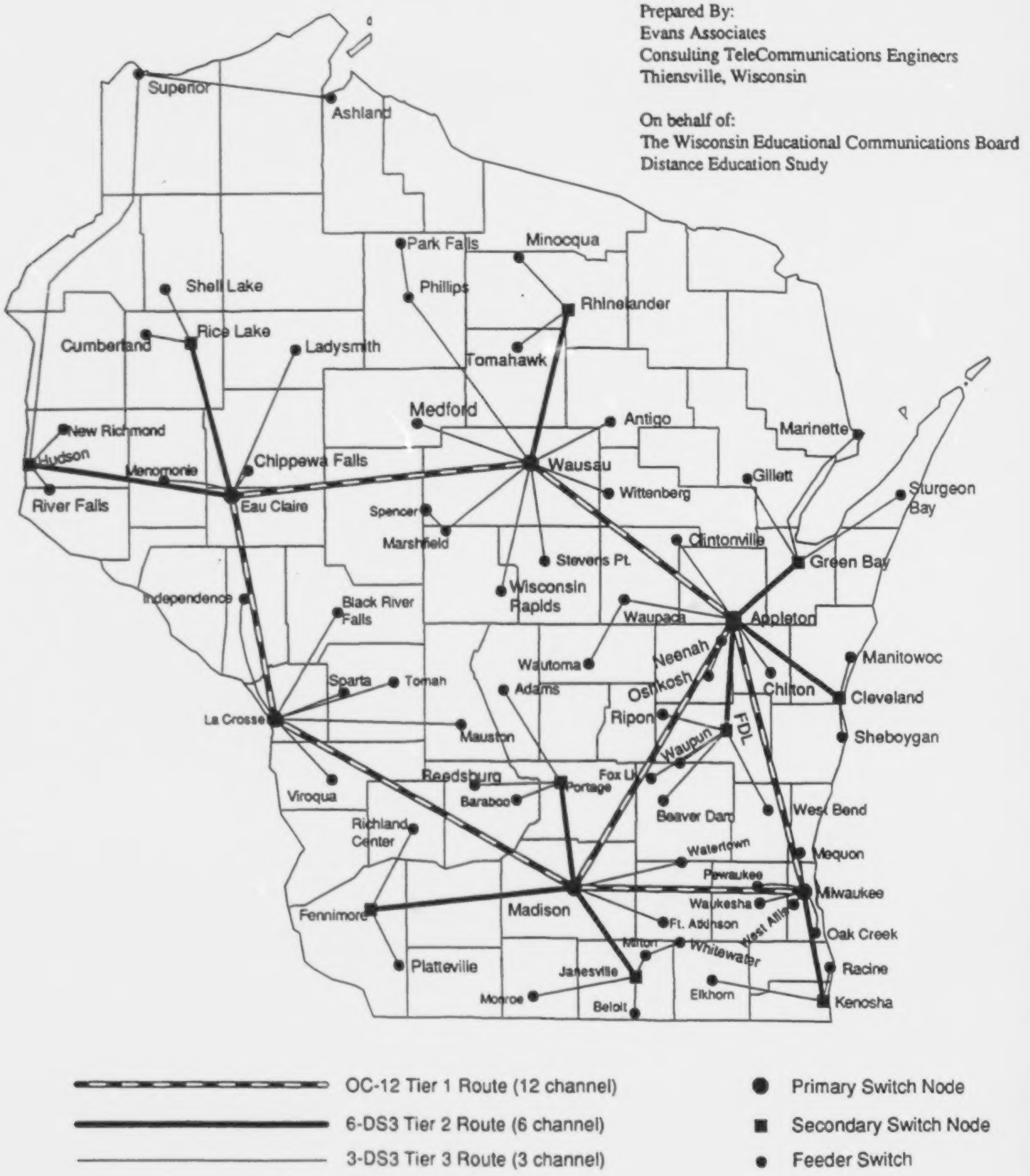
APPENDIX A-1

WISCONSIN OVERLAY DISTANCE EDUCATION NETWORK (WODIE)

Wisconsin's Data Highway ... A Vision For The Future

Prepared By:
Evans Associates
Consulting TeleCommunications Engineers
Thiensville, Wisconsin

On behalf of:
The Wisconsin Educational Communications Board
Distance Education Study


Superior
Ashland
Park Falls
Minocqua
Phillips
Rhinelander
Shell Lake
Rice Lake
Cumberland
Ladysmith
Tomahawk
Medford
Antigo
Marinette
New Richmond
Hudson
Menomonie
Chippewa Falls
Wausau
Gillett
Sturgeon Bay
River Falls
Eau Claire
Wittenberg
Spencer
Marshfield
Clintonville
Stevens Pt.
Green Bay
Wisconsin Rapids
Independence
Black River Falls
Waupaca
Appleton
Neenah
Oshkosh
Manitowoc
Wautoma
Adams
Chilton
Cleveland
Sparta
Tomah
La Crosse
Ripon
FDL
Sheboygan
Mauston
Waupun
Reedsburg
Fox Lk
Portage
Baraboo
Viroqua
Beaver Dam
West Bend
Richland Center
Watertown
Mequon
Pewaukee
Milwaukee
Waukesha
Fennimore
Madison
Ft. Atkinson
West Allis
Oak Creek
Milton
Whitewater
Platteville
Janesville
Racine
Elkhorn
Monroe
Beloit
Kenosha
OC-12 Tier 1 Route (12 channel)
6-DS3 Tier 2 Route (6 channel)
3-DS3 Tier 3 Route (3 channel)
Primary Switch Node
Secondary Switch Node
Feeder Switch

NOTES: 1) Last mile local loops and individual endpoints are not shown
2) Channels may be used for video, voice or data

APPENDIX A-2

WISCONSIN OVERLAY DISTANCE EDUCATION NETWORK (WODIE)

What is the WODIE network?

The Wisconsin Overlay Distance Education Network would be a statewide super highway for the long distance transportation of video, data and voice traffic. This network would interconnect public colleges, private colleges, vocational schools, K-12 districts, libraries, hospitals and businesses located throughout the state.

Why is this network needed?

The overlay network is needed to allow local distance education systems to share course materials, conduct video conferences and interconnect computers in a cost-effective and compatible manner. Without a centrally-administered overlay network, the different interconnect standards used by local systems and the consequent duplication of control equipment would vastly increase the aggregate cost of distance education in Wisconsin.

Who could use this network?

Educational institutions at all levels, state and local government agencies, hospitals, libraries and businesses could use the WODIE network for educational purposes.

What are the potential uses of the network?

It is anticipated that the network will be applied toward educational and administrative activities in the following functional areas:

- Credit and non-credit courses
- Administrative telephone traffic
- Non-traditional student education (homebound, prison inmate, etc.)
- Staff development
- Administrative teleconferencing and computer data transmission
- Computer functions (multi-media, library, student registration and records)

Input is being sought from all interested parties concerning potential uses of the network. Please address your comments to: Larry Dickerson, Wisconsin Educational Communications Board, 3319 W. Beltline Hwy., Madison, WI 53713, (608) 264-9666.

What institutions and agencies have demonstrated a specific need for this network?

A statewide *Needs Assessment* has concluded that this overlay network is needed to allow effective use of technology resources on behalf of the following entities:

- State agencies such as the Dept. of Corrections (DOC), Dept. of Transportation (DOT), Dept. of Natural Resources (DNR), Dept. of Justice (DOJ), and Dept. of Public Instruction (DPI)
- Local High Schools
- Technical Colleges (VTAE), UW Campuses, and Private Colleges & Universities
- Businesses and Hospitals
- County and City Governments
- Local and Regional Libraries

Who would construct and administer the network?

The network would be constructed under a state lease contract employing existing vendors such as AT&T, MCI, GTE, Sprint, MRC, Wisconsin Bell and independent telephone companies; the network therefore would make maximum use of existing state resources. Vendors would be selected for cost-effectiveness and flexibility of service. A *system integrator* would acquire capacity for the network while a *user committee* would schedule the network programming.

What are the projected capabilities of this network?

The following uses are envisioned for the network:

- Telephone traffic
- Television video and graphics
- Computer data
- Video teleconferencing
- High Definition TV for medical and similar applications

The network is designed to be dynamic in its capacity allocation so that institutions will not have to pay for capability they do not need. Ultimately, "switched" video and data capacity may be obtained on demand in a manner similar to today's voice telephone network.

What resources does Wisconsin have that could assist in the creation of this network?

Wisconsin possesses the following resources which could assist in the implementation of the network:

- State-owned tower sites for placement of (microwave) antenna dishes
- Extensive fiber optic cable operated by regulated common carriers
- Unregulated vendors of fiber optic cable and microwave capability
- Personnel skilled in network management and technical maintenance
- Existing local distance education networks in many parts of the state

How can money be saved with this network?

The Wisconsin Educational Communications Board (WECB), the Dept. of Administration (DOA), DOT, DOC, other Wisconsin state agencies and local educational institutions spend millions of dollars annually on video, data and voice transportation obtained from private vendors. This traffic is increasing exponentially throughout the state. By consolidating traffic, sharing resources and centralizing the leasing process, long-term savings can be achieved in a manner similar to the State Telephone System (STS). While user fees would probably be assigned, they will be considerably lower than existing long distance rates for similar services.

What are other states doing?

Iowa and Indiana have built statewide fiber overlay networks. Illinois, Minnesota and Michigan are building mixed-technology networks to carry educational and state government traffic.

What has been done so far in Wisconsin?

Regional entities and school districts, recognizing the need for video, data and voice networks, have banded together to form regional consortia. Many of these consortia have already implemented *local* distance education networks. The purpose of the WODIE overlay network would be to join the regional networks together into a statewide system.

What are the benefits? What are the risks?

The creation of the WODIE network would equalize educational opportunity throughout the state and would provide extended continuing education choices in the work place and at home for both students and instructors.

Risks include the possibility that some regional networks and local institutions will be incompatible with the system. Steps must also be taken to minimize the adverse effect that rapid advances in technology may have on the network. For instance, long term leases may lock in a higher cost for services which may be priced significantly lower in the future.

How do we migrate toward this statewide network goal?

The WECB *Needs Assessment* revealed that extensive state resources exist which are currently being used for video, data and voice transportation functions. Ideally, the WODIE regional interconnect system would be realized via a migration path which includes the existing technology mix to the maximum extent possible.

Over what timeframe might this migration occur?

The network as pictured here probably will take up to ten years to fully implement, assuming that today's budget dollar availability does not change significantly. The intercity "primary" routes would be among the first links to be installed with other regional routes being added as funding becomes available.

In the meantime, local consortia will be encouraged to coordinate their technical standards so that all of the regional networks will be compatible with each other. Coordination of fund raising efforts will also be encouraged so that grant money will be spent efficiently. Such coordination will eliminate duplication of effort and minimize obsolescence.

What technologies would be used for the overlay network?

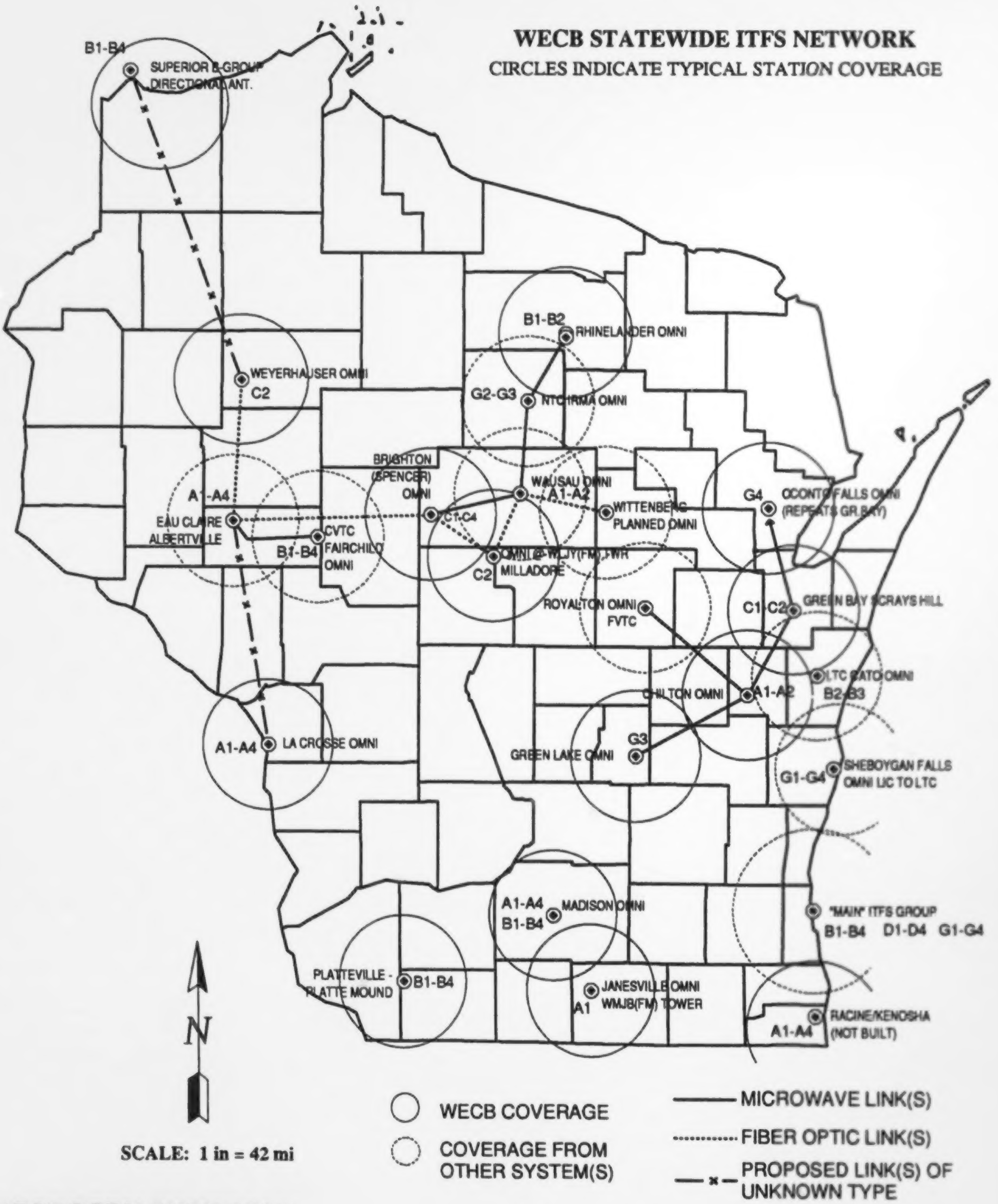
Ultimately, the primary links forming the WODIE redundant "double ring" would be composed entirely of fiber optic cable. During the migration period, interim use of microwave and satellite is contemplated both to handle peak capacity and to fill in gaps where fiber is not available. During the short term, the technologies used to reach the end users will continue to be those in use today: television, microwave, Cable TV and telephone lines. As the network migration progresses, more of the local interconnect functions will be accomplished via fiber optic cable.

What are the major issues affecting the creation of the WODIE network?

- State executive and legislative commitment
- Staff allocations and review of regulations at the Dept. of Administration (DOA) and the Public Service Commission (PSC)
- Front-end financing to realize long-term economic benefits
- Support of other interested groups
- Establishment of an administrative body and user partnership
- Maximum participation by all

4/93

.WODIE



WECB STATEWIDE ITFS NETWORK

CIRCLES INDICATE TYPICAL STATION COVERAGE

B1-B4
SUPERIOR E-GROUP DIRECTIONAL ANT.
WEYERHAUSER OMNI
C2
B1-B2
RHINELANDER OMNI
G2-G3
NTC-IRMA OMNI
BRIGHTON (SPENCER) OMNI
C1-C4
WAUSAU OMNI
A1-A2
WITTENBERG PLANNED OMNI
G4
OCONTO FALLS OMNI (REPEATS GR BAY)
A1-A4
EAU CLAIRE ALBERTVILLE
B1-B4
CVTC FAIRCHILD OMNI
OMNI @ WLJY(FM) TWR
C2
MILLADORE
ROYALTON OMNI FVTC
C1-C2
GREEN BAY SCRAYS HILL
LTC GATO OMNI
B2-B3
CHILTON OMNI
A1-A2
G3
GREEN LAKE OMNI
A1-A4
LA CROSSE OMNI
G1-G4
SHEBOYGAN FALLS OMNI LIC TO LTC
A1-A4
B1-B4
MADISON OMNI
"MAIN" ITFS GROUP
B1-B4 D1-D4 G1-G4
PLATTEVILLE - PLATTE MOUND
B1-B4
JANESVILLE OMNI WMJB(FM) TOWER
A1
RACINE/KENOSHA (NOT BUILT)
A1-A4
N
SCALE: 1 in = 42 mi
WECB COVERAGE
COVERAGE FROM OTHER SYSTEM(S)
MICROWAVE LINK(S)
FIBER OPTIC LINK(S)
PROPOSED LINK(S) OF UNKNOWN TYPE

BEST COPY AVAILABLE

ITFS STATIONS LOCATED IN THE STATE OF WISCONSIN
(Includes *some* stations from surrounding states)

City	Chan	St	Call	Auth	Date_ent	COORDINATES						Tpo	POL	Ant Ht AGL	Ant Ht AMSL	Ant Type	
ANTIGO	G2	WI	WHR945	CP	02/12/91	45	7	36	89	7	58	10.00	V	151.00	1637.00	DISH	NORTH CENTRAL TECH COLLEGE
APPLETON	D1	WI	WHR786	CP	02/05/91	44	17	0	88	27	30	10.00	H	70.00	860.00	DISH	STATE OF WISC EDUC COMM BOARD
APPLETON	E1-E4	WI	NEW	APP	02/05/91	44	7	10	88	28	24	10.00	V	295.00	1047.00		PAUL COMMUNICATIONS, INC.
APPLETON	F1-F4	WI	NEW		02/05/91	44	15	42	88	25	12	0.00	?	0.00	0.00		MICROBAND CORP. OF AMERICA
BRIGHTON	C1-C4	WI	NEW	APP	02/05/91	44	49	35	90	14	28	10.00	H	0.00	0.00		STATE OF WISC EDUC COMM BOARD
BUFFALO	G1-G4	MN	WHR847	CP	02/12/91	45	11	31	93	52	18	10.00	H	246.00	1257.00		SHELBURNE WRIGHT ED-TECH
CATO	B2	WI	WHR921	CP	02/05/91	44	6	55	87	51	27	10.00	H	272.00	1171.00	OMNI	LAKESHORE TECHNICAL COLLEGE
CATO	B3	WI	WHR921	CP	02/05/91	44	6	55	87	51	27	10.00	H	272.00	1171.00	OMNI	LAKESHORE TECHNICAL COLLEGE
CHICAGO	C1-C4	IL	WAC262	LIC	11/04/91	41	52	44	87	38	10	10.00	H	1450.00	2044.00	DIR	CATHOLIC BISHOP OF CHICAGO
CHICAGO	D1	IL	NEW-I	APP	11/04/91	41	52	44	87	38	10	6.46	V	1450.00	2044.00	DIR	CHICAGO INSTR TECH FOUND
CHICAGO	D3	IL	NEW-I	APP	11/04/91	41	52	44	87	38	10	6.46	V	1450.00	2044.00	DIR	CHICAGO INSTR TECH FOUND
CHICAGO	E1-E4	IL	WBH648	LIC	11/04/91	41	52	44	87	38	10	10.00	H	1453.00	2047.00		ILLINOIS INSTITUTE OF TECHNOLOGY
CHICAGO	F1-F4	IL	WHK999	LIC	11/04/91	41	53	56	87	37	23	10.00	V	1138.00	1732.00	DIR	ARNOLD MALKAN
CHICAGO	G1-G4	IL	WHG269	LIC	11/04/91	41	52	44	87	38	10	10.00		1450.00	2044.00		ILLINOIS INSTITUTE OF TECHNOLOGY
CHICAGO	H1	IL	WHEL393	LIC	11/04/91	41	53	56	87	37	23	0.00	V	171.00	0.00		AMERICAN COMMUNICATIONS
CHICAGO	H3	IL	WNET334	LIC	11/04/91	41	53	56	87	37	23	0.00		0.00	0.00		PEOPLE'S CHOICE TV PARTNERS
CHILTON/OSHKOSH	A1-A2	WI	WHR591	LIC	02/05/91	44	1	42	88	17	8	10.00	H	250.00	1378.00	OMNI	STATE OF WISC EDUC COMM BOARD
CHILTON/OSHKOSH	A3-A4	WI	WHR591	CP	02/06/91	44	1	42	88	17	8	10.00	H	250.00	1378.00	OMNI	STATE OF WISC EDUC COMM BOARD
CITY POINT	E1-E4	WI	NEW	APP	10/25/91	44	21	15	90	17	30	10.00	H	194.00	1175.00		NORTHEASTERN COMMUNICATIONS
CLEVELAND	B1	WI	WHR922	CP	02/05/91	43	55	30	87	45	6	10.00	H	89.00	0.00	DISH	LAKESHORE TECHNICAL COLLEGE
CLEVELAND	B4	WI	WHR922	CP	02/05/91	43	55	30	87	45	6	10.00	H	89.00	0.00	DISH	LAKESHORE TECHNICAL COLLEGE
COLFAX	H1	WI	NEW	APP	02/12/91	44	57	39	91	4	5	10.00	V	351.00	1621.00	OMNI	IVAN C NACMAN
COLFAX	H2	WI	NEW	APP	02/12/91	44	57	39	91	40	5	10.00	V	351.00	1621.00	OMNI	JOHN DUDECK
COLFAX	H3	WI	NEW	APP	02/12/91	44	57	39	91	40	5	10.00	V	351.00	1621.00		BLAKE TWEDT
DE PERE	H2	WI	WNTF959	LIC	02/05/91	44	24	1	88	0	37	10.00	V	194.00	1112.00		JOSEPH L. ROFFERS
DECORAH	F1-F4	IA	NEW	CP	02/12/91	43	17	54	91	47	30	0.00		0.00	0.00		MULTICHANNEL MEDIA INC
DES PLAINES	B3-B4	IL	WHR498	CP	11/04/91	42	3	37	87	52	49	10.00	V	105.00	738.00	DIR	BD OF TRUSTEES,COM COL DI

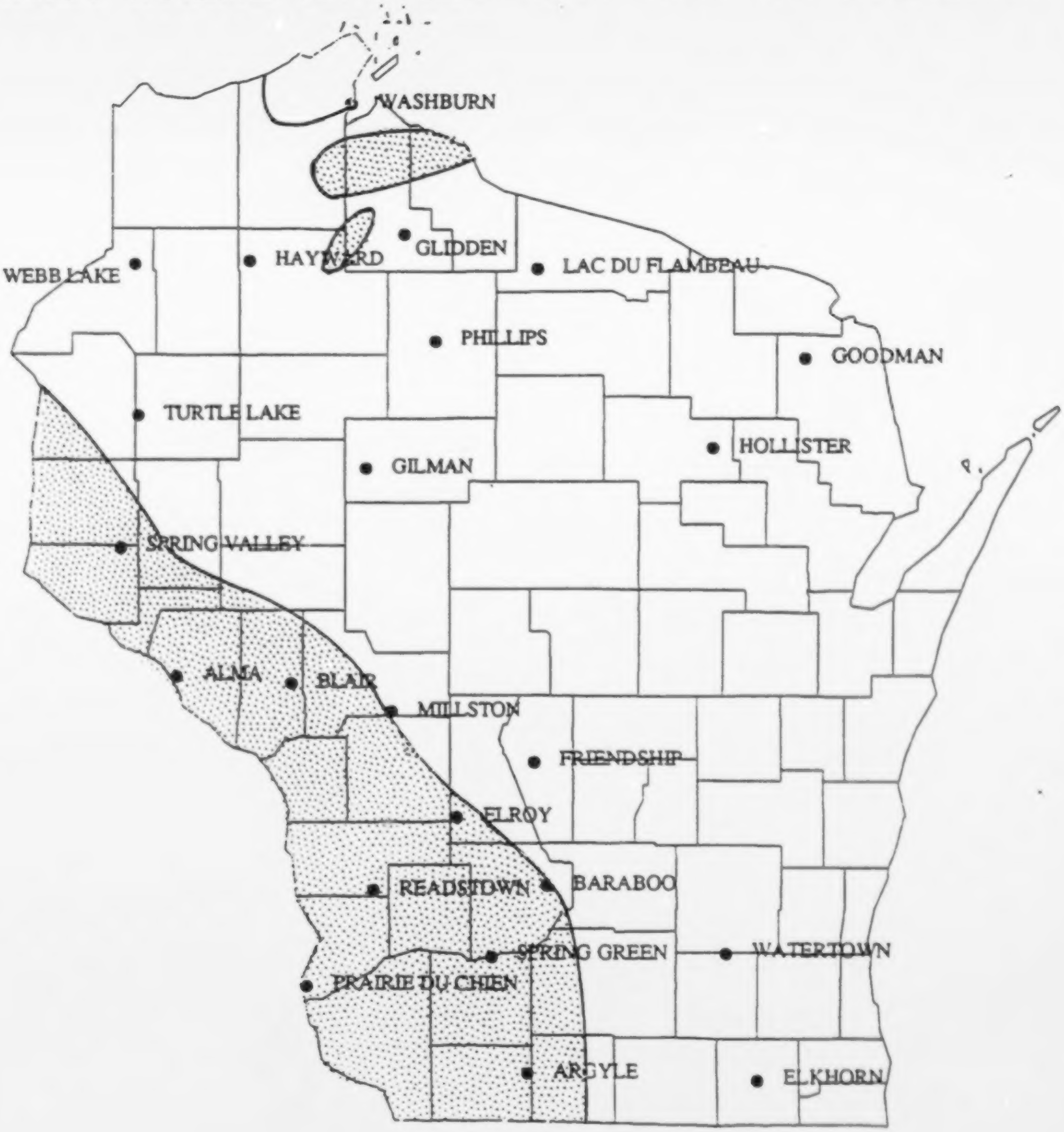
City	Chan	St	Call	Auth	Date_ent	COORDINATES						Tpo	P O L	Ant Ht AGL	Ant Ht AMSL	Ant Type
DOVER	G1	WI	WHR952	CP	02/12/91	45	40	20	90	8	42	10.00	H	80.00	1794.00	DISH NORTH CENTRAL TECH INST.
EAU CLAIRE	A1-A2	WI	WHR648	LIC	02/12/91	44	53	1	91	35	12	10.00	H	371.00	1381.00	OMNI STATE OF WISC EDUC COMM BOARD
EAU CLAIRE	A3-A4	WI	WHR648	CP	02/12/91	44	53	1	91	35	12	10.00	H	371.00	1381.00	OMNI STATE OF WISC EDUC COMM BOARD
EAU CLAIRE	D1	WI	WHR849	CP	02/12/91	44	47	39	91	30	20	1.00	H	46.00	935.00	DISH STATE OF WISC EDUC COMM BOARD
EAU CLAIRE	D2	WI	WLX-366	LIC	02/06/92	44	47	55	91	30	1	4.00	H	44.00	834.00	DISH STATE OF WISC EDUC COMM BOARD
EAU CLAIRE	D4	WI	WHR979	CP	02/12/91	44	47	38	91	31	22	3.00	V	154.00	994.00	DISH STATE OF WISC EDUC COMM BOARD
EAU CLAIRE	E1-E4	WI	NEW	APP	02/12/91	44	48	48	91	29	42	0.00		0.00	0.00	MIDWESTERN RELAY COMPANY
EAU CLAIRE	H1	WI	NEW	APP	02/12/91	44	51	43	91	52	36	0.00		0.00	0.00	BGR WIRELESS
EGG HARBOR	E1-E4	WI	NEW	APP	10/25/91	45	2	30	87	15	44	10.00	H	194.00	892.00	NORTHEASTERN COMMUNICATIONS
EGG HARBOR	F1-F4	WI	NEW	APP	10/25/91	45	2	30	87	15	44	10.00	H	194.00	892.00	PREMIERE TV, LTD.
ELBURN	G1-G4	IL	NEW-I	APP	11/04/91	41	53	42	88	32	58	10.00	V	197.00	1227.00	DIR NATL CONF ON CITIZENSHIP
EVANSTON	B3-B4	IL	NEW-I	APP	11/04/91	42	3	13	87	40	35	4.50	H	118.00	719.00	DIR? NORTHWESTERN UNIVERSITY
EVANSTON	G3-G4	IL	NEW-I	APP	11/04/91	42	3	13	87	40	35	4.50	H	118.00	719.00	NORTHWESTERN UNIVERSITY
FAIRCHILD	B1-B4	WI	WLX260	CP	02/12/91	44	43	40	90	56	32	10.00	V	322.00	1552.00	OMNI CHIPPEWA VALLEY TECH COLL
FOND DU LAC	G4	WI	CP	APP	10/25/91	43	47	6	88	24	36	2.00	V	49.00	813.00	DISH STATE OF WISC EDUC COMM BOARD
GRANTON	B4	WI	NEW		02/05/91	44	35	36	90	27	47	10.00	H	0.00	0.00	DISH STATE OF WISC EDUC COMM BOARD
GREEN BAY	C1-C2	WI	WHR632	LIC	02/05/91	44	24	32	88	0	12	10.00	V	233.00	1142.00	OMNI STATE OF WISC EDUC COMM BOARD
GREEN BAY	C3-C4	WI	WHR632	CP	02/05/91	44	24	32	88	0	12	10.00	H	233.00	1142.00	OMNI STATE OF WISC EDUC COMM BOARD
GREEN BAY	D1	WI	WHR938	CP	02/05/91	44	31	7	88	5	58	4.00	H	75.00	755.00	DISH STATE OF WISC EDUC COMM BOARD
GREEN BAY	D2	WI	WLX208	LIC	02/05/91	44	31	7	88	5	58	4.00	H	75.00	755.00	DISH STATE OF WISC EDUC COMM BOARD
GREEN BAY	D4	WI	WHR874	CP	02/05/91	44	31	53	87	55	16	4.00	H	131.00	791.00	DISH STATE OF WISC EDUC COMM BOARD
GREEN BAY	E1-E4	WI	WLW981	CP	02/05/91	44	30	40	88	2	10	10.00	V	174.00	764.00	OMNI FORTUNA SYSTEMS CORP.
GREEN BAY	F1-F4	WI	WLW980	CP	02/05/91	44	30	40	88	2	10	10.00	V	174.00	764.00	OMNI MWTV, INC.
GREEN BAY	H1	WI	WNTI809	LIC	02/05/91	44	24	1	88	0	37	10.00	V	194.00	1112.00	OMNI DIANE MADDOX
GREEN BAY	H3	WI	WNTI811	LIC	10/30/91	44	24	1	88	0	37	0.00	V	194.00	1112.00	ALYSSA E BLAKE
GREEN LAKE	G3	WI	WLX301	CP	10/25/91	43	45	28	88	58	15	10.00	H	270.00	1350.00	OMNI STATE OF WISC EDUC COMM BOARD
HOLCOMBE	C4	WI	NEW	APP	07/17/92	45	16	48	91	12	56	2.00	V	75.00	1595.00	DISH STATE OF WISC EDUC COMM BOARD
IRMA	G2	WI	WHR950	APP	02/12/91	45	19	47	89	38	48	10.00	V	194.00	1903.00	OMNI NORTH CENTRAL TECH COLLEGE
IRMA	G3	WI	WHR950	CP	02/12/91	45	19	47	89	38	48	10.00	V	194.00	1903.00	OMNI NORTH CENTRAL TECH COLLEGE
IRMA	G4	WI	WHR960	CP	02/12/91	45	19	47	89	38	48	10.00	H	151.00	1860.00	DISH NORTH CENTRAL TECHNICAL COLLEGE

City	Chan	St	Call	Auth	Date_ent	COORDINATES						Tpo	POL	Ant Ht AGL	Ant Ht AMSL	Ant Type	
JANESVILLE	E1-E4	WI	WLW807	CP	11/04/91	42	39	35	89	2	32	10.00	V	95.00	935.00	OMNI	MULTI POINT TV DIST INC.
JANESVILLE	F1-F4	WI	NEW	APP	11/04/91	42	39	35	89	2	52	0.00		0.00	0.00		MULTI MICRO
LA CROSSE	A1-A2	WI	WHR576	LIC	02/12/91	43	48	15	91	14	30	10.00	H	138.00	807.00	OMNI	STATE OF WISC EDUC COMM BOARD
LA CROSSE	A3-A4	WI	WHR576	CP	02/12/91	43	48	15	91	14	30	10.00	H	138.00	807.00	OMNI	STATE OF WISC EDUC COMM BOARD
LA CROSSE	D1	WI	WHR936	CP	02/12/91	43	48	52	91	14	51	1.00	V	82.00	758.00	DISH	STATE OF WISC EDUC COMM BOARD
LA CROSSE	D4	WI	WHR935	CP	02/12/91	43	48	11	91	13	43	1.00	V	79.00	748.00	DISH	STATE OF WISC EDUC COMM BOARD
LA CROSSE	E1-E4	WI	NEW	APP	02/12/91	43	50	48	91	13	8	10.00	V	538.00	1178.00		HOME-SYSTEM JOINT VENTURE
LADYSMITH	C3	WI	WLX233	CP	07/16/92	45	28	19	91	4	38	2.00	H	83.00	1263.00	DISH	STATE OF WISC EDUC COMM BOARD
LONG LAKE	C1	WI	WLX246	CP	02/12/91	45	40	0	91	40	6	10.00	H	400.00	1716.00	DIR	STATE OF WISC EDUC COMM BOARD
LOYAL	B2	WI	NEW		02/05/91	44	44	12	90	30	9	10.00	H	0.00	0.00	DISH	STATE OF WISC EDUC COMM BOARD
MADISON	A1-A4	WI	NEW-I		08/16/88	43	3	18	89	28	42	10.00	V	400.00	1449.00	DIR	MADISON AREA TECHNICAL COLLEGE
MADISON	B1-B4	WI	WHR626	LIC	02/18/91	43	3	18	89	28	42	10.00	V	600.00	1649.00	OMNI	STATE OF WISC EDUC COMM BOARD
MADISON	C3	WI	WHR907	CP	10/25/91	43	4	35	89	25	54	1.00	V	187.00	1076.00	DISH	STATE OF WISC EDUC COMM BOARD
MADISON	D1-D4	WI	WHR815	CP	10/25/91	43	7	16	89	19	45	10.00	H	400.00	1450.00	DISH	AREA VO-TECH ADULT EDUCATION
MAUSTON	H1-H3	WI	NEW	APP	10/25/91	43	47	16	90	11	52	10.00	H	52.00	1378.00	OMNI	FONVU PARTNERS
MEDFORD	G2	WI	WHR946	CP	02/12/91	45	7	41	90	20	10	10.00	V	200.00	1650.00		NORTH CENTRAL TECH INST
MENOMONIE - deleted	D3	WI	WHR990	CP	02/12/91	44	52	33	91	55	40	5.00	H	131.00	991.00		STATE OF WISC EDUC COMM BOARD
MILLADORE	C2	WI	NEW	APP	10/25/91	44	38	41	89	51	11	10.00	V	600.00	1800.00	OMNI	STATE OF WISC EDUC COMM BOARD
MILWAUKEE	A1-A4	WI	WHR514	LIC	02/18/91	43	2	18	87	54	5	10.00	V	598.00	1215.00	DIR	NETWORK FOR INSTR TV
MILWAUKEE	B1-B4	WI	KHF80	APP	10/25/91	43	4	42	87	52	57	10.00	V	443.00	1119.00	DIR	MILWAUKEE BOARD OF SCHOOL DIRS
MILWAUKEE	D1-D4	WI	WDG56	APP	10/25/91	43	4	42	87	52	57	10.00	V	450.70	1126.70	DIR	BOARD OF REGENTS - UNIV OF WISC
MILWAUKEE	G1-G4	WI	WHR810	APP	10/25/91	43	4	42	87	52	57	10.00	V	443.00	1119.00	DIR	MILW AREA DIST BOARD OF VOC, TEC
MILWAUKEE	H1	WI	WNEI904		02/04/91	43	2	18	87	54	5	0.00	H	0.00	0.00		AMERICAN COMMUNICATIONS
MILWAUKEE	H2	WI	WHJ939	LIC	02/04/91	43	2	18	87	54	5	0.00	V	607.00	1224.00		VIA-NET CO.
MILWAUKEE	H3	WI	WNEY686	LIC	10/25/91	43	2	18	87	54	5	0.00		0.00	0.00		BROADCAST DATA CORP.
MILWAUKEE/WOOD	E1-E2	WI	WAU27		02/04/91	43	1	17	87	58	35	10.00	H	0.00	0.00		MILW REG MED INST TV STA
MINNEAPOLIS	A1-A4	MN	NEW-I	APP	02/12/91	44	58	32	93	16	18	10.00	V	814.00	1663.00		MINN PUBLIC RADIO INC
MINNEAPOLIS	C1-C4	MN	WIG33	LIC	02/12/91	44	58	32	93	13	57	0.10	V	92.00	932.00		UNIVERSITY OF MINNESOTA
MINNEAPOLIS	D1-D4	MN	WLX200	CP	02/12/91	44	58	31	93	16	19	10.00	V	814.00	1663.00		BD OF ED, SPECIAL SCH DIST
MINNEAPOLIS	E1-E4	MN	WHT677	APP	02/12/91	44	58	32	93	16	18	10.00	V	105.00	945.00		THEODORE D. LITTLE

City	Chan	St	Call	Auth	Date_ent	COORDINATES						Tpo	POL	Ant Ht AGL	Ant Ht AMSL	Ant Type	
MINNEAPOLIS	E1-E4	MN	WIG35	LIC	02/12/91	44	58	28	93	16	17	10.00	V	0.00	0.00		UNIV OF MINNESOTA
MINNEAPOLIS	F1-F4	MN	WHT678	LIC	02/12/91	44	58	32	93	16	18	10.00	V	791.00	1644.00		SCOLLARD COMMUNICATIONS
MINNEAPOLIS	G1-G4	MN	WHR487	CP	02/12/91	44	58	32	93	16	18	10.00	H	791.00	1644.00		TWIN CITIES SCH TELEC COM
MINNEAPOLIS	H1	MN	WNEY683	LIC	02/12/91	44	58	32	93	16	18	0.00		0.00	0.00		BROADCAST DATA CORP.
MINNEAPOLIS	H2	MN	WNEZ819	LIC	02/12/91	44	58	32	93	16	18	0.00		0.00	0.00		SPECCHIO DEVELOPERS LIMIT
MINNEAPOLIS	H3	MN	WNTA934	LIC	02/12/91	44	58	31	93	16	19	0.00		0.00	0.00		NASHVILLE LOW POWER TV CO
MINNEAPOLIS/MAPLE GROVE	A2-A4	MN	KVI64	APP	02/12/91	44	58	32	93	16	18	10.00	H	791.00	1644.00		INDEPENDENT SCHOOL DIST. #279
MINNEAPOLIS/ROCHESTER	G1-G4	MN	WIG34	LIC	02/12/91	44	21	2	92	46	53	10.00	V	394.00	1644.00		REGENTS OF THE U OF MN
MINNEAPOLIS/SAINT PAUL	B1-B4	MN	WHR497	CP	02/12/91	44	58	32	93	16	18	10.00	H	791.00	1644.00		MINN PUB RADIO
MINNEAPOLIS/SAINT PAUL	C1-C4	MN	WHR636	LIC	02/12/91	44	58	32	93	16	18	10.00	V	787.00	1640.00		REGENTS OF THE UNIV OF MINNESOTA
MUNDELEIN	F1-F4	IL	WAH800	LIC	11/04/91	42	17	13	87	59	40	10.00	V	341.00	1109.00		CATHOLIC BISHOP OF CHICAGO
OCONTO FALLS	G4	WI	WLX302	CP	10/25/91	44	51	26	88	9	37	10.00	H	255.60	1015.60	OMNI	STATE OF WISC EDUC COMM BOARD
OSHKOSH	D2	WI	WLX342	CP	10/25/91	44	1	5	88	33	15	4.00	H	75.00	827.00	DISH	STATE OF WISC EDUC COMM BOARD
OSHKOSH	D3	WI	WHR937	CP	02/05/91	44	1	45	88	33	8	4.00	H	108.00	877.00	DISH	STATE OF WISC EDUC COMM BOARD
PARK FALLS	B1-B4	WI	WHR628	CP	02/04/91	45	56	43	90	16	28	10.00	V	300.00	1880.00	DIR	WISC EDUC COMM BOARD
PHILLIPS	G3	WI	WHR951	CP	02/12/91	45	42	27	90	25	12	10.00	H	79.00	0.00		NORTH CENTRAL TECH COLL.
PLATTEVILLE	B1-B2	WI	WHR630	LIC	02/18/91	42	45	51	90	24	19	10.00	V	100.00	1050.00	DIR	STATE OF WISC EDUC COMM BOARD
PLATTEVILLE	B3-B4	WI	NEW	CP	02/18/91	42	45	51	90	24	19	10.00	V	100.00	1050.00	DIR	STATE OF WISC EDUC COMM BOARD
POSTVILLE	E1	IA	NEW	APP	02/12/91	43	4	48	91	33	32	0.00		0.00	0.00		NORTHEAST IOWA TV, INC.
POSTVILLE	F1	IA	NEW	APP	02/12/91	43	4	48	91	33	32	0.00		0.00	0.00		POSTVILLE-TELE CO.
POSTVILLE	H1	IA	WNTC415	LIC	02/12/91	43	4	48	91	33	32	0.00		0.00	0.00		POSTVILLE TELEPHONE CO.
RHINELANDER	B1-B2	WI	WHR856	CP	02/12/91	45	36	45	89	24	56	10.00	H	331.00	1936.00	OMNI	WISC EDUC COMM BOARD
RHINELANDER	C3	WI	WHR955	CP	02/12/91	45	36	46	89	24	56	10.00	H	200.00	1805.00	DISH	NICOLET COLLEGE & TECH INSTITUTE
RHINELANDER	C4	WI	WHR954	CP	02/12/91	45	36	45	89	24	56	10.00	H	330.00	1935.00	OMNI	NICOLET COLLEGE & TECH INST
RICE LAKE	C4	WI	WLX239	CP	02/12/91	45	28	52	91	44	46	2.00	H	75.00	1204.00	DISH	STATE OF WISC EDUC COMM BOARD
RICEVILLE	F1-F4	IA	NEW	APP	02/12/91	43	23	11	92	29	29	10.00	V	482.00	1854.00		JEWEL TELECOMMUNICATIONS
RICEVILLE	H1	IA	WNTE490	LIC	02/12/91	43	23	11	92	29	29	0.00		0.00	0.00		MICHELE ZAHN
RICEVILLE	H2	IA	WNTG438	LIC	02/12/91	43	23	11	92	29	29	0.00		0.00	0.00		JEWEL TELECOMMUNICATIONS
RICEVILLE	H3	IA	WNTE612	LIC	02/12/91	43	23	11	92	29	29	0.00		0.00	0.00		TC COMMUNICATIONS INC
RIVER GROVE	B1-B2	IL	WHM934	LIC	11/04/91	41	54	56	87	50	12	10.00	V	151.00	784.00	OMNI	TRITON COMMUNITY COLLEGE

City	Chan	St	Call	Auth	Date_ent	COORDINATES						Tpo	POL	Ant Ht AGL	Ant Ht AMSL	Ant Type	
ROCHESTER	B1-B4	MN	WHR753	CP	02/12/91	44	1	11	92	28	39	10.00	V	128.00	1253.00		MINN PUBL RADIO INC
ROCHESTER	E1-E4	MN	NEW-I	APP	02/12/91	44	2	39	92	23	56	10.00	H	256.00	1496.00		L.E.O. BROADCASTING INC.
ROCK TOWNSHIP	A2	WI	WLX-284	APP	11/04/91	42	35	39	89	1	1	1.00	H	75.00	876.00	DISH	STATE OF WISC EDUC COMM BOARD
SHEBOYGAN	F1-F4	WI	NEW	APP	10/25/91	43	45	5	87	42	43	10.00	V	118.00	236.00	OMNI	BROADCAST DATA CORP
SHEBOYGAN FALLS	G2-G4	WI	WHR458		02/05/91	43	42	12	87	45	9	10.00	H	305.00	978.00	OMNI	LAKESHORE TECHNICAL COLLEGE
SOMERS	A1-A4	WI	WHR766	CP	02/18/91	42	37	1	87	52	28	10.00	H	276.00	1322.00	DIR	STATE OF WISC EDUC COMM BOARD
SPENCER	B1	WI	WLX-348	CP	02/05/91	44	45	32	90	17	36	1.00	H	0.00	0.00	DISH	STATE OF WISC EDUC COMM BOARD
STEVENS POINT	C1	WI	WLX-373	LIC	10/25/91	44	31	36	89	34	14	2.00	V	121.00	1211.00	DISH	STATE OF WISC EDUC COMM BOARD
STRATFORD	B3	WI	WLX-349	CP	02/05/91	44	48	22	90	4	29	4.00	H	75.00	1316.00	DISH	STATE OF WISC EDUC COMM BOARD
SUGAR GROVE	A1-A4	IL	WHR850	CP	02/18/91	41	47	50	88	27	25	10.00	V	0.00	180.00	OMNI	WAUBONSEE COMM COLLEGE
SUPERIOR (DULUTH MN)	B1-B4	WI	WHR-627	CP	07/15/92	46	47	21	92	6	52	10.00	H	57.00	1301.00	DIR	STATE OF WISC EDUC COMM BOARD
SUPERIOR	C1	WI	WLX-258	CP	07/15/92	46	43	4	92	5	20	1.00	H	47.00	682.00	DISH	STATE OF WISC EDUC COMM BOARD
SUPERIOR	E1-E4	WI	NEW	APP	02/12/91	46	32	4	92	4	5	10.00	H	400.00	1470.00		DONALD M STOWE
TOWN OF MAGNOLIA	A1	WI	NEW	APP	02/04/91	42	43	38	89	15	2	10.00	H	400.30	1328.70	OMNI	STATE OF WISC EDUC COMM BOARD
WASECA	H1	MN	NEW	APP	02/12/91	44	1	12	93	28	31	0.00		0.00	0.00		MICHELE ZAHN
WASECA	H2	MN	NEW	APP	02/12/91	44	1	12	93	28	31	0.00	V	486.00	1690.00		JEWEL TELECOMMUNICATIONS
WASECA	H3	MN	NEW	APP	02/12/91	44	1	12	93	28	31	0.00	V	486.00	1690.00		TC COMMUNICATIONS INC
WAUSAU	A1-A4	WI	WHR580	LIC	02/04/91	44	55	14	89	41	31	10.00	H	0.00	0.00	OMNI	WISC EDUC COMM BOARD
WAUSAU	D1-D3	WI	WHR799	CP	02/12/91	44	59	11	89	38	39	2.00	H	53.00	1266.00	DISH	STATE OF WISC EDUC COMM BOARD
WAUSAU	G1	WI	WHR948	CP	02/12/91	44	53	17	89	39	7	10.00	V	150.00	1722.00	DISH	NORTHCENTRAL TECHNICAL COLLEGE
WAUSAU	G4	WI	WHR949	CP	02/12/91	44	59	11	89	38	39	5.00	V	53.00	1268.00	DISH	NORTH CENTRAL TECHNICAL COLLEGE
WAUSAU	H1	WI	NEW	APP	02/12/91	44	58	30	89	40	9	0.00	H	194.00	1690.00		JRZ ASSOCIATES INCORPORAT
WAUSAU	H1	WI	NEW	APP	02/12/91	44	58	58	89	36	6	0.00	V	436.00	1844.00		ROUNDTREE COMMUNICATIONS
WAUSAU	H2	WI	NEW	APP	02/12/91	44	58	30	89	40	9	0.00	H	194.00	1690.00		LIBMOT COMMUNICATIONS PAR
WEYERHAUSER	C2	WI	WLX232	CP	02/12/91	45	25	16	91	25	10	10.00	V	399.00	1604.00	OMNI	STATE OF WISC EDUC COMM BOARD
WINNETKA	A1-A4	IL	KGZ66	LIC	02/12/91	42	5	40	87	43	7	10.00	H	157.00	771.00		BD OF EDUC OF TWP HIGH, DIS

AREA WHERE ITFS USE MAY NOT BE OPTIMUM


WASHBURN
WEBB LAKE
HAYWARD
GLIDDEN
LAC DU FLAMBEAU
PHILLIPS
GOODMAN
TURTLE LAKE
HOLLISTER
GILMAN
SPRING VALLEY
ALMA
BLAIR
MILLSTON
FRIENDSHIP
ELROY
READSTOWN
BARABOO
SPRING GREEN
WATERTOWN
PRAIRIE DU CHIEN
ARGYLE
ELKHORN

● POSSIBLE NEW ITFS

▨ ADVERSE TERRAIN CONDITIONS

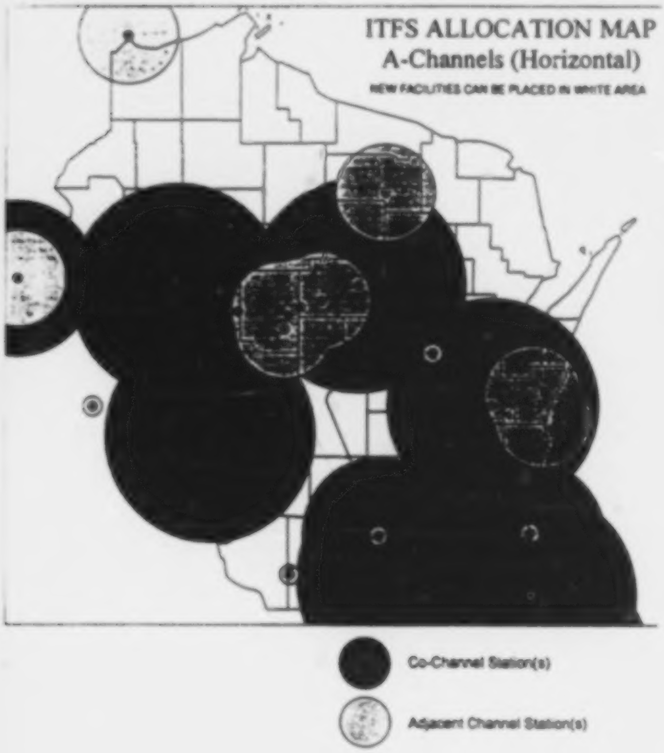
Evans Associates

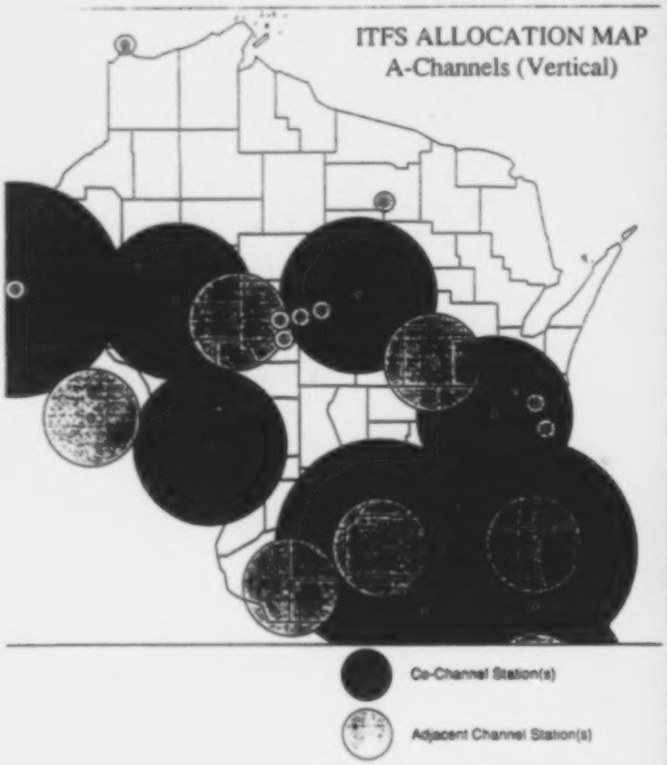
BEST COPY AVAILABLE

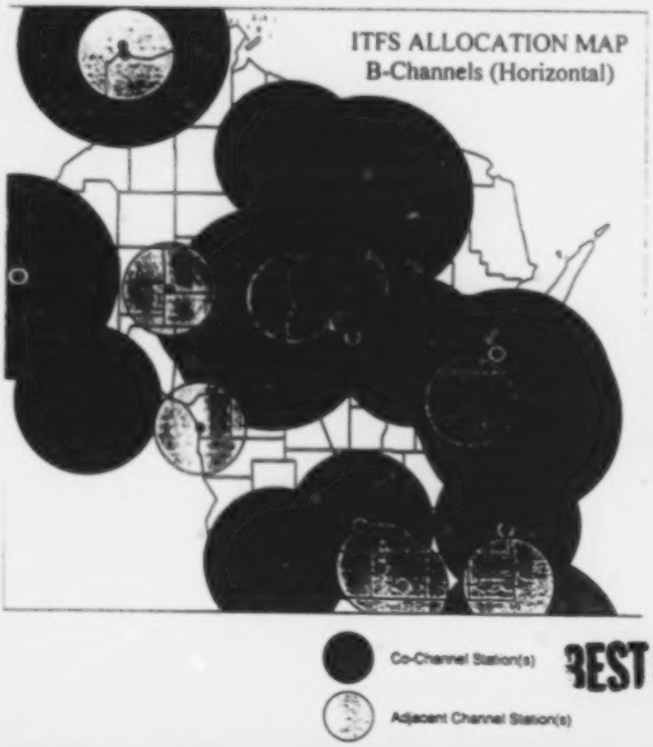
POSSIBLE NEW ITFS STATIONS IN WISCONSIN

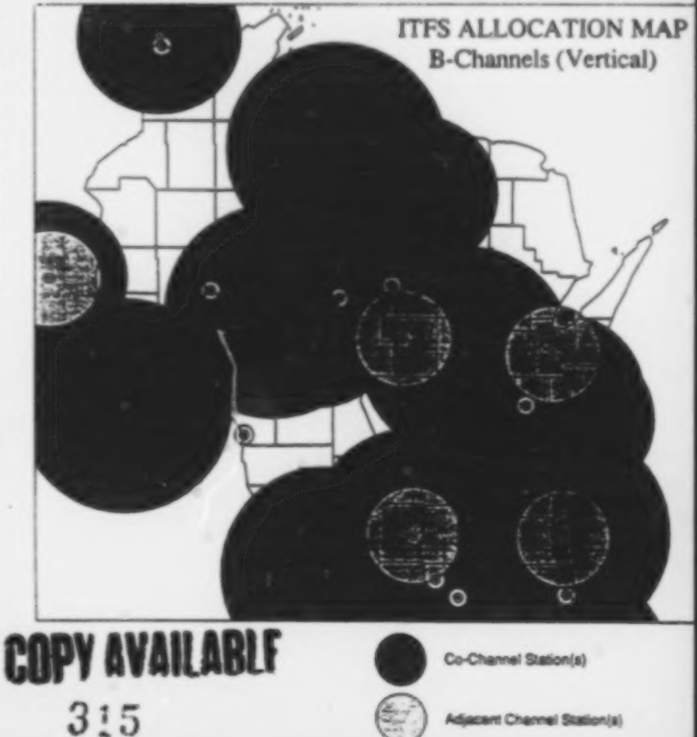
	Channel	Coordinates	City
1	A (H)	(43.972000 - 89.817000)	Friendship
2	C (H)	(43.190000 - 88.720000)	Watertown
3	G (H)	(42.673000 - 88.543000)	Elkhorn
4	G (H)	(42.700000 - 89.863000)	Argyle
5	G (V)	(43.470000 - 89.745000)	Baraboo
6	D (V)	(43.178000 - 90.070000)	Spring Green
7	A (V)	(43.052000 - 91.147000)	Prairie du Chien
8	B (H)	(43.450000 - 90.757000)	Readstown
9	C (V)	(43.745000 - 90.273000)	Elroy
10	G (H)	(44.180000 - 90.650000)	Millston
11	C (H)	(44.295000 - 91.230000)	Blair
12	G (H)	(44.321000 - 91.905000)	Alma
13	B (V)	(44.847000 - 92.238000)	Spring Valley
14	G (V)	(45.393000 - 92.138000)	Turtle Lake
15	A (V)	(45.172000 - 90.803000)	Gilman
16	A (V)	(45.254036 - 88.794521)	Hollister
17	D (V)	(45.621207 - 88.265472)	Goodman
18	D (V)	(45.991955 - 89.803961)	Lac du Flambeau
19	A (H)	(46.009849 - 92.157588)	Webb Lake
20	D (H)	(46.023000 - 91.482000)	Hayward
21	G (V)	(46.670000 - 90.893000)	Washburn
22	A (H)	(45.800000 - 90.370000)	Phillips (north of)

APPENDIX B-9

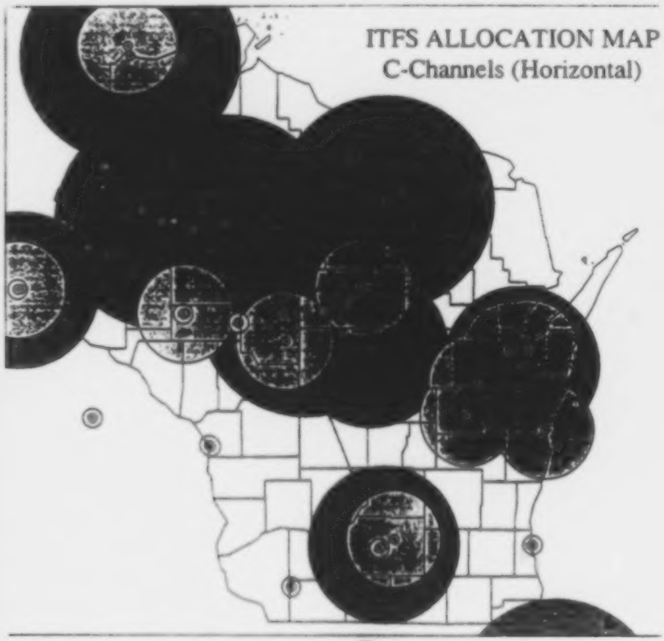

ITFS ALLOCATION MAP
A-Channels (Horizontal)
NEW FACILITIES CAN BE PLACED IN WHITE AREA
Co-Channel Station(s)
Adjacent Channel Station(s)


ITFS ALLOCATION MAP
A-Channels (Vertical)
Co-Channel Station(s)
Adjacent Channel Station(s)


ITFS ALLOCATION MAP
B-Channels (Horizontal)
Co-Channel Station(s)
Adjacent Channel Station(s)

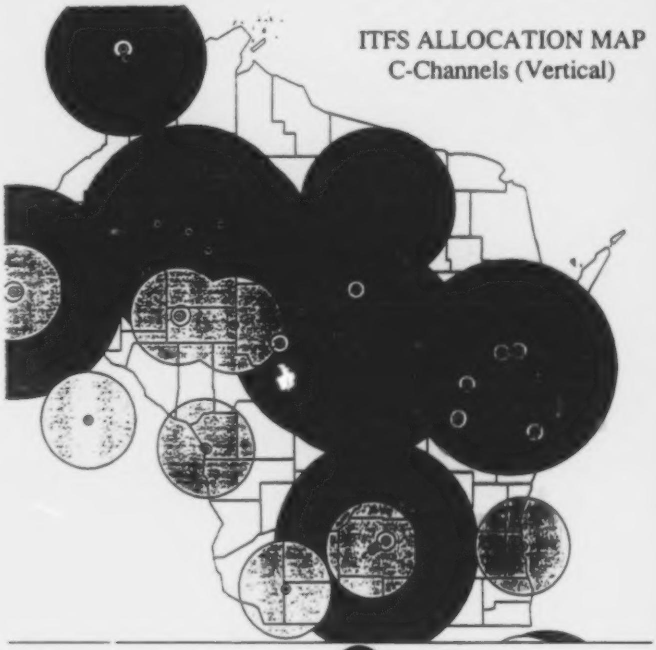

ITFS ALLOCATION MAP
B-Channels (Vertical)
Co-Channel Station(s)
Adjacent Channel Station(s)

BEST COPY AVAILABLE


ITFS ALLOCATION MAP
C-Channels (Horizontal)

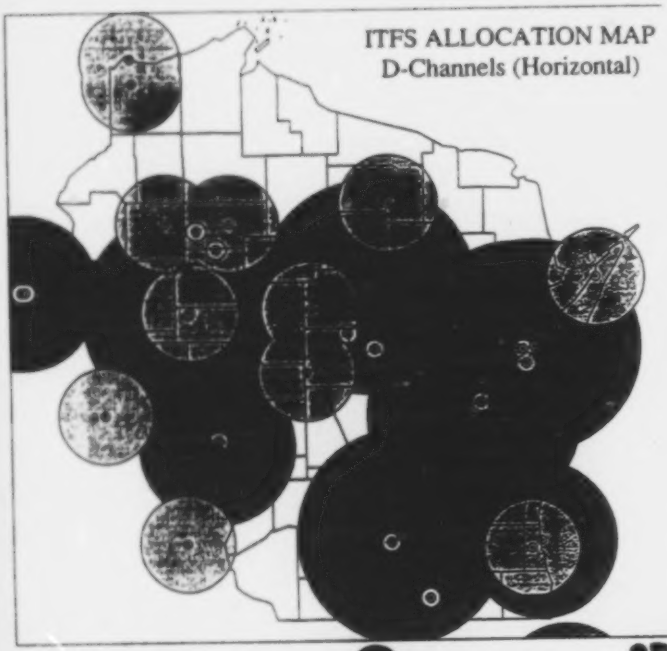
● Co-Channel Station(s)

▨ Adjacent Channel Station(s)


ITFS ALLOCATION MAP
C-Channels (Vertical)

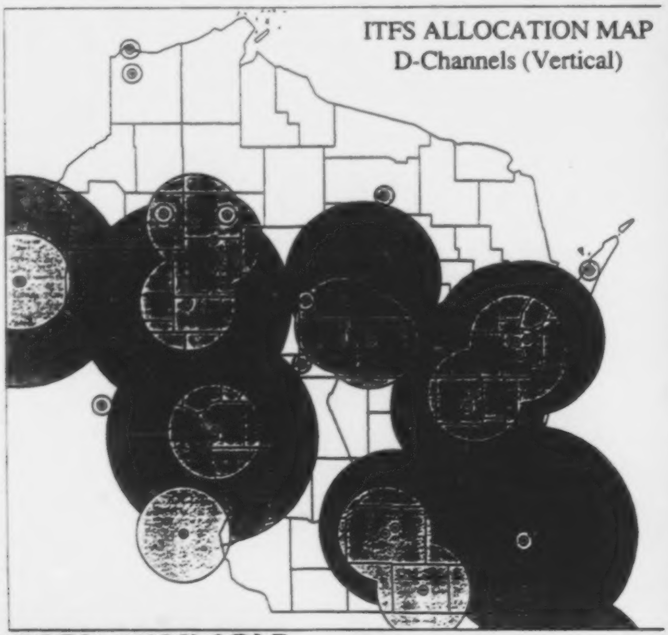
● Co-Channel Station(s)

○ Adjacent Channel Station(s)


ITFS ALLOCATION MAP
D-Channels (Horizontal)

● Co-Channel Station(s)

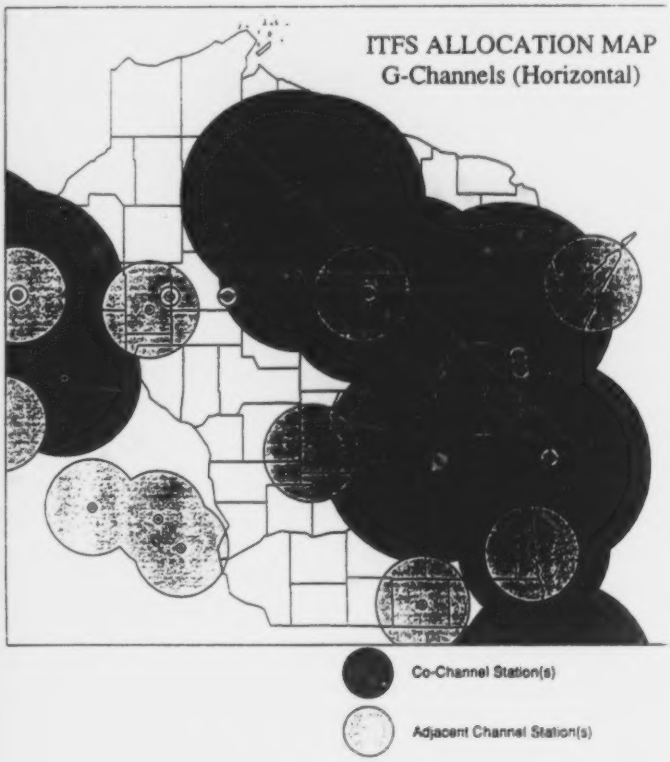
▨ Adjacent Channel Station(s)

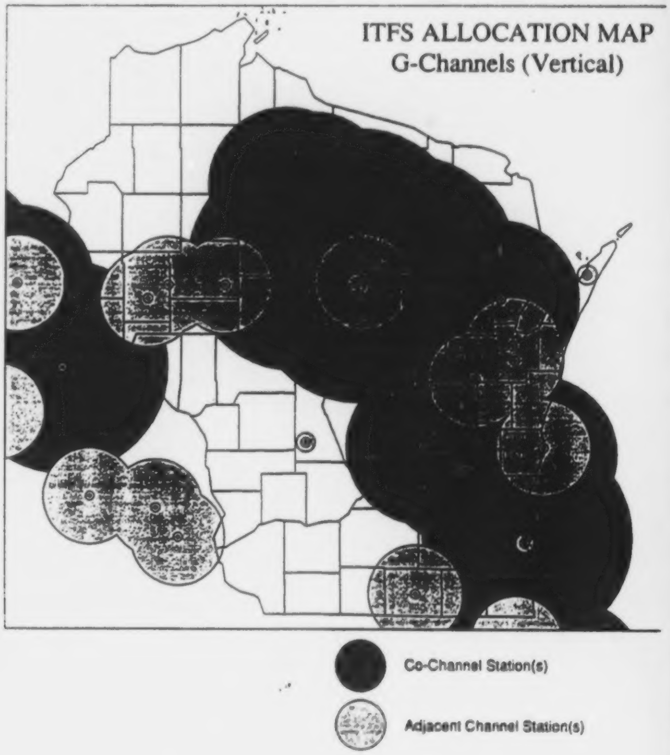

ITFS ALLOCATION MAP
D-Channels (Vertical)

● Co-Channel Station(s)

▨ Adjacent Channel Station(s)

BEST COPY AVAILABLE


ITFS ALLOCATION MAP
G-Channels (Horizontal)
Co-Channel Station(s)
Adjacent Channel Station(s)


ITFS ALLOCATION MAP
G-Channels (Vertical)
Co-Channel Station(s)
Adjacent Channel Station(s)

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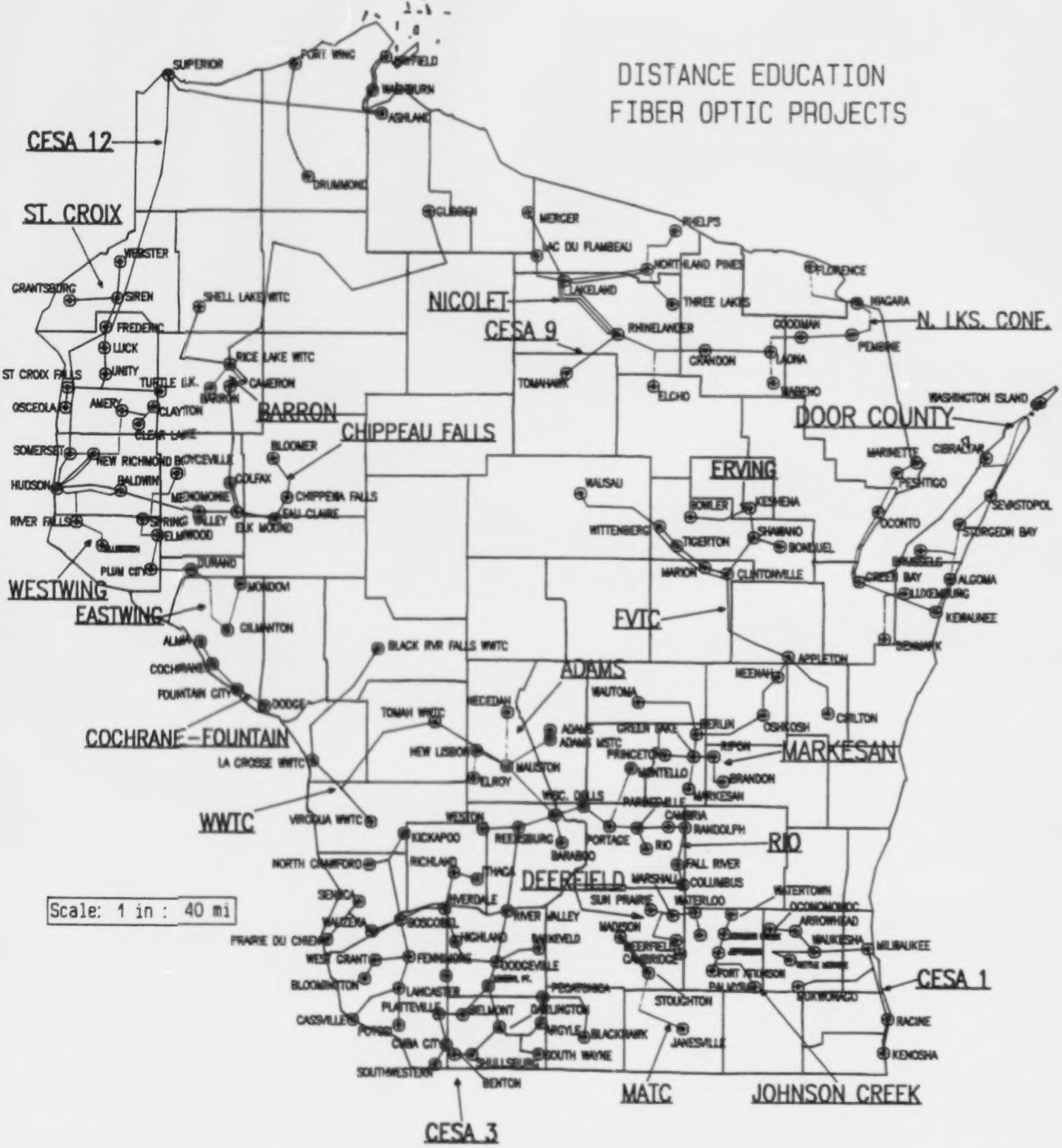
DISTANCE EDUCATION FIBER OPTIC PROJECTS


CESA 12
ST. CROIX
NICOLET
CESA 9
N. LKS. CONF.
BARRON
CHIPPEAU FALLS
DOOR COUNTY
ERVING
FVTC
WESTWING
EASTWING
ADAMS
MARKESAN
COCHRANE-FOUNTAIN
WWTC
RIO
DEERFIELD
CESA 1
MATC
JOHNSON CREEK
CESA 3
Scale: 1 in : 40 mi
SUPERIOR
PORT WING
BAYFIELD
WASHBURN
ASHLAND
DRUMMOND
GLIDDEN
MERCER
LAC DU FLAMBEAU
PHELPS
NORTHLAND PINES
FLORENCE
LAKELAND
THREE LAKES
NIAGARA
RHINELANDER
GOODMAN
PEMBINE
CRANDON
LAONA
WABENO
TOMAHAWK
ELCHO
WASHINGTON ISLAND
WEBSTER
GRANTSBURG
SIREN
SHELL LAKE WITC
FREDERIC
LUCK
UNITY
ST CROIX FALLS
TURTLE LK.
RICE LAKE WITC
CAMERON
BARRON
OSCEOLA
AMERY
CLAYTON
CLEAR LAKE
SOMERSET
NEW RICHMOND
BOYCEVILLE
BLOOMER
HUDSON
BALDWIN
COLFAX
MENOMONIE
CHIPPEWA FALLS
EAU CLAIRE
RIVER FALLS
SPRING VALLEY
ELMWOOD
ELK MOUND
PLUM CITY
DURAND
MONDOVI
GILMANTON
ALMA
COCHRANE
FOUNTAIN CITY
DODGE
BLACK RVR FALLS WWTC
MARINETTE
GIBRALTAR
PESHTIGO
SEVASTOPOL
STURGEON BAY
OCONTO
BRUSSELS
GREEN BAY
ALGOMA
LUXEMBURG
KEWAUNEE
DENMARK
WAUSAU
BOWLER
KESHENA
WITTENBERG
SHAWANO
TIGERTON
BONDUEL
MARION
CLINTONVILLE
APPLETON
NEENAH
CHILTON
WAUTOMA
HEWEDAH
TOMAH WWTC
ADAMS
ADAMS WSTC
GREEN LAKE
BERLIN
OSHKOSH
RIPON
NEW LISBON
MAUSTON
PRINCETON
MONTELLO
BRANDON
LA CROSSE WWTC
ELROY
MARKESAN
WISC. DELLS
PARDEEVILLE
CAMBRIA
VIROQUA WWTC
WESTON
KICKAPOO
REEDSBURG
PORTAGE
RANDOLPH
RIO
BARABOO
NORTH CRAWFORD
RICHLAND
ITHACA
FALL RIVER
MARSHALL
COLUMBUS
SUN PRAIRIE
WATERLOO
WATERTOWN
OCONOMOWOC
SENECA
RIVERDALE
WAUZEKA
BOSCOBEL
RIVER VALLEY
ARROWHEAD
PRAIRIE DU CHIEN
HIGHLAND
BARNEVELD
MADISON
DEERFIELD
CAMBRIDGE
WAUKESHA
MILWAUKEE
WEST GRANT
FENNIMORE
DODGEVILLE
BLOOMINGTON
FORT ATKINSON
PALMYRA
MUKWONAGO
LANCASTER
PECATONICA
STOUGHTON
CASSVILLE
PLATTEVILLE
BELMONT
DARLINGTON
RACINE
POTOSI
ARGYLE
BLACKHAWK
JANESVILLE
CUBA CITY
SHULLSBURG
SOUTH WAYNE
KENOSHA
SOUTHWESTERN
BENTON

BEST COPY AVAILABLE

Id	Name	Cover*	A/P+	-- Voice -- 1-way	2-Way	-- Data -- 1-Way	2-Way	-- Video -- 1-Way	2-Way	Primary Technology	Contact Institution
AgSat	Agriculture Satellite Network	N	A	N	N	N	N	Y	N	Satellite	
CENTERSNET	UW Centers Network	S	A	N	N	N	Y	N	N	Phone Lines	UW-Stevens Point
CHILTON	Chilton	R	A	N	Y	N	N	Y	N	ITFS	FVTC/NTC/ECB/NEWTEC
CTN			A	N	Y	N	N	N	N	Phone Lines	CESA
CVTCITV	CVTC Interactive Television	R	A	N	Y	N	N	N	Y	ITFS/Microwv	
CWETN	Loyal/Granton/Stratford/Spenc	R	A	N	Y	N	N	Y	Y	ITFS	CESA 10
Cent Sands	Central Sands, Stevens Point	R	A	Y	N	N	N	Y	N	ITFS	UW-Stevens Point
DCAIN	Dane County Area ITFS Network	R	A	N	Y	N	N	Y	N	ITFS	CESA 2/ECB/UW/MATC
DOC	Dept of Corrections		A	N	N	N	N	N	N		
Door Cnty	Door County		P	N	N	N	N	Y	N	ITFS	
ERIC		S	A	N	N	Y	N	N	N		
ERVING		R	A	N	Y	N	N	N	Y	Fiber	
ETN			A	N	Y	N	N	N	N	Phone Lines	
EastWING	East Wisc Instruc Network Grp	R	A	N	Y	N	Y	N	Y	Fiber	
FEMA			A	Y	N	N	N	Y	N	Satellite	FEMA
GRADES	Green/Rock Area Dist Ed System	R	A	N	Y	N	N	Y	N	ITFS	CESA 2/Blackhawk
Hillsboro			A	N	Y	N	Y	N	Y	Fiber	
ITV		S	A	Y	N	N	N	Y	N	Broadcast TV	WECB
LTC	Lakeshore Technical College	R	A	N	Y	N	N	Y	N	ITFS	Lakeshore Tech Coll
MAIN	Milwaukee Area Instruc Ntwrk	R	A	N	Y	N	N	Y	N	ITFS	MPS/UWM/MATC
MODUMATH			A	Y	N	Y	N	Y	N	S'ware/Laser	VTAE Foundation
Moraine	Moraine Park Technical College	R	P	N	Y	N	N	Y	N	ITFS	MPTC
NATC	Nicolet Area Tech College	R	A	N	Y	N	N	Y	N	ITFS	NATC/ECB
NEWTEC	NE Wis Telecomm Educ Consortim	R	A	N	Y	N	N	Y	N	ITFS	NEWTEC/CESA 7/CESA
NTU	National Technological Univ	N	A	N	Y	N	N	Y	N	Satellite	
NWECS	NW Wis Ed Comm System	R	A	N	Y	N	Y	N	Y	Fiber	CESA 12
PBS VSAT		N	A	N	Y	N	Y	N	Y	Satellite	WECB
Rice Lake			A	N	N	N	N	N	N	Fiber	

*: S=Statewide; R=Regional; N=Nationwide   +: A=Actual, P=Planned

Id	Name	Cover*	A/P+	— Voice — 1-way	2-Way	— Data — 1-Way	2-Way	— Video — 1-Way	2-Way	Primary Technology	Contact Institution
SAP			A	N	N	N	N	N	N		
SCA			A	Y	N	N	N	N	N		
SCIN	South-Central Instruc Network		A	N	Y	N	Y	N	Y	Fiber	CESA 5
SERC		N	A	N	Y	N	N	Y	N	Satellite	
SWTC	SW Technical College	R	A	N	Y	N	N	Y	N	ITFS/Cable	SWTC/CESA 3/UW-P
TCA	Technical College of the Air	S	A	Y	N	N	N	Y	N	Cable/Video	VTAE
TCCC	Trempeleau County Comm Coop	R	A	Y	N	N	N	Y	N	Cable	
UW-Eau Cl	Eau Claire Area	R	A	N	Y	N	N	Y	N	ITFS	UWEC/ECB/CVTC
UW-Marshfl	UW-Marshfield		A	N	N	N	N	N	N		
UW-SUP	UW-Superior	R	A	N	Y	N	N	Y	N	ITFS	UWS/ECB
VBI			A	N	N	N	N	N	N		
Vernon Cty	Vernon County Coop		A	N	Y	N	Y	N	Y	Fiber	
WANUC	Wausau Area Narrowcast Usrs Gr	R	A	N	Y	N	N	N	Y	ITFS/Microwv	NTC
WIN	Wisc Indianhead Narrowcast	R	A	N	Y	N	N	Y	N	ITFS	WITC
WISCAT		S	A	N	N	Y	N	N	N	CD-ROM	
WISCNET			A	N	N	N	Y	N	N	Phone Lines	UW-Madison
WISCONLINK			A	N	N	N	N	N	N	Satellite	Lakeshore Tech
WISLINE			A	N	Y	N	N	N	N	Phone Lines	
WISPALS		R	A	N	N	N	Y	N	N		Blackhawk Tech?
WISSAT		S	A	Y	N	N	N	Y	N	Satellite	UW-Ex Coop
WISVIEW			A	N	Y	N	Y	N	N	Phone Lines	
WONDER	West Central WI Planning Grp	R	P	N	Y	N	Y	N	Y	Fiber	Consortium
WPTN	Wisconsin Public TV Network	S	A	Y	N	N	N	Y	N	Broadcast TV	WECB
WWTC	West Wisc Tech College	R	A	N	Y	N	N	Y	N	ITFS/Cable	Trempealeau
WestWING	West Wisc Instruc Network Grp	R	A	N	Y	N	Y	N	Y	Fiber	

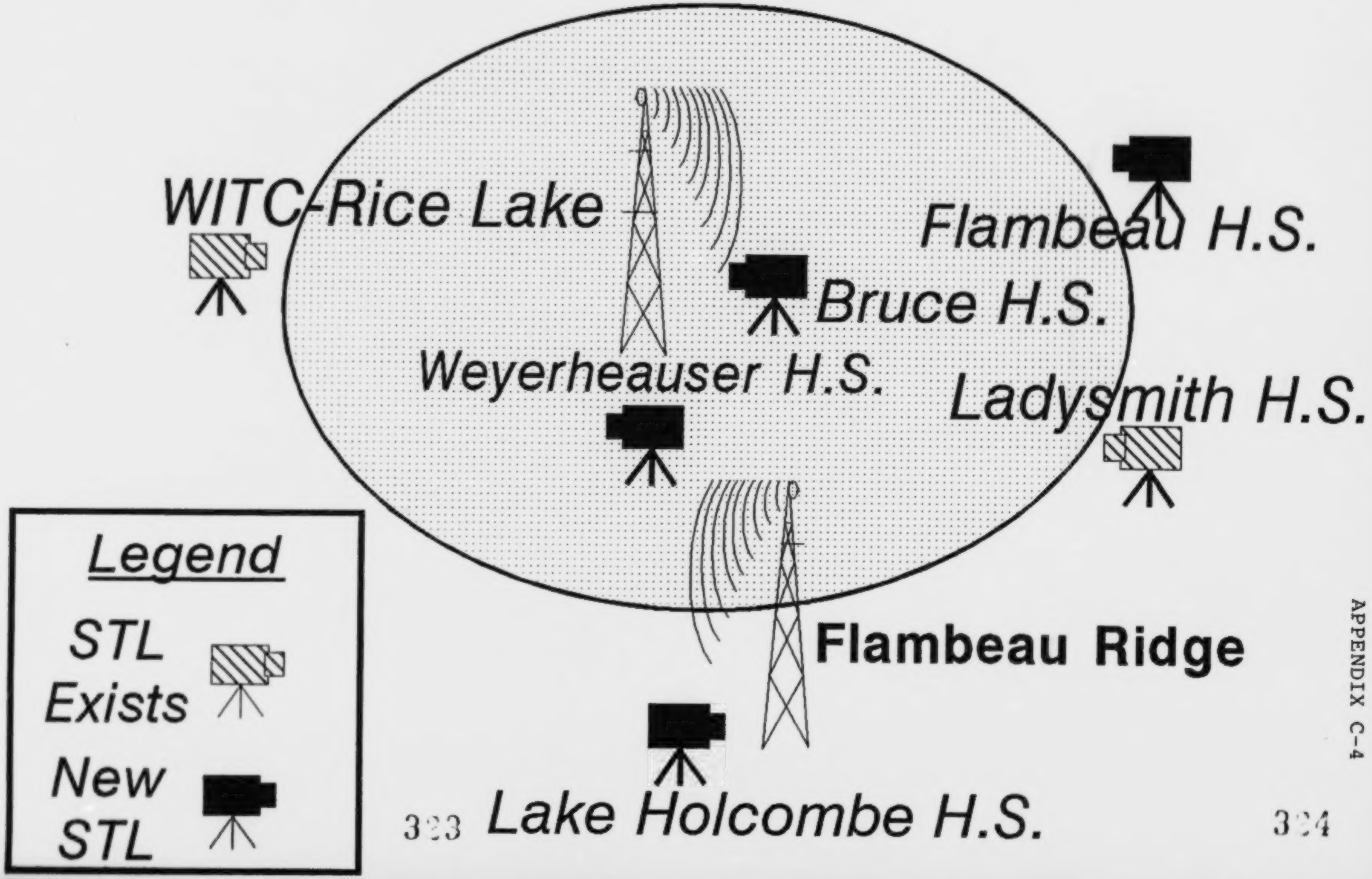
*: S=Statewide; R=Regional; N=Nationwide +: A=Actual, P=Planned

Distance Education IT Funding Requests

No.	Project Name	Description	Engineering	Capital/Lease
01	Central Sands Consortia DE Enhancement Project	Link existing ITFS into other projects	0	$283,000
02	WIN Network Upgrade	Upgrade existing ITFS system to 2-way	$11,643	$429,842
03	Coulee Regional Distance Education Project	Fiber Link to five or more schools in Vernon County	$7,000	$1,219,395
04	CVTC Upgrade	Add 2-way microwave to existing CVTC system	0	$1,067,333
05	CWETN/Mosinee Hill Enhancement	Add two-way microwave link to link CWETN with DC Everest	$30,000	$122,500
06	Dane/Jefferson Area Interactive Distance Learning Network	Interconnect MATC campuses, CESA 2, K-12s, and Blackhawk TC	$5,000	$1,975,000
07	Door/Kewaunee/Marinette Distance Learning Network	Fiber optic network in Door County	0	$719,928
08	East Central Fiber Optic Interlink	Fiber links between FVTC, ERVING and NTC	$8,000	$640,200
09	FVTC Interactive Network	Fiber from FVTC to 10 locations within district	$6,000	$1,940,000
10	Interactive Distance Learning Network	Fiber link between UW-Stout and UW-Platteville	$10,075	$209,924
11	Nicolet Northwoods DE Project	Fiber link between Nicolet TC and area K-;12 schools	$5,500	$1,219,680
12	Pharmacy Technician	Fiber links to provide pharmacy tech training	0	$90,000
13	~~South Central Wisconsin~~	~~Fiber link of elementary and secondary schools~~	0	$0
14	UWEC, SJH, TC, CWETN Interconnect	Fiber link from UW-Eau Claire to St. Joseph's Hospital, Project Circuit, and CWETN	$15,000	$175,000
15	WANUC ITFS Expansion	ITFS transmitters at Irma & Wittenberg	$5,000	$147,600
16	WCWC Interactive Sharing Network	Compressed video link between four UW campuses and other projects	$10,075	$273,504
17	West Central Wisconsin Interconnect Network	Fiber links between eleven distance education systems and institutions.	0	$1,870,600
18	WestWING	Fiber link between nine K-12, WITC and UW-River Falls	$5,000	$969,408
19	~~WI DOC ITFS~~	~~ITFS link to provide training to Oshkosh Correctional Inst~~		$0
20	WW-La Crosse Instructional Microwave Network	Microwave link of UW-La Crosse into La Crosse ITFS system	$5,000	$143,800
21	WWTC Distance Ed Project	Fiber link to five WWTC campuses	$75,000	$1,375,122
22	NWECS Fiber Optic Project	Additional funding for existing NWECS project-lease cost for 17 institutions for 9 years x $12,500.		$1,912,500
		Total	**198,293**	**$16,784,336**

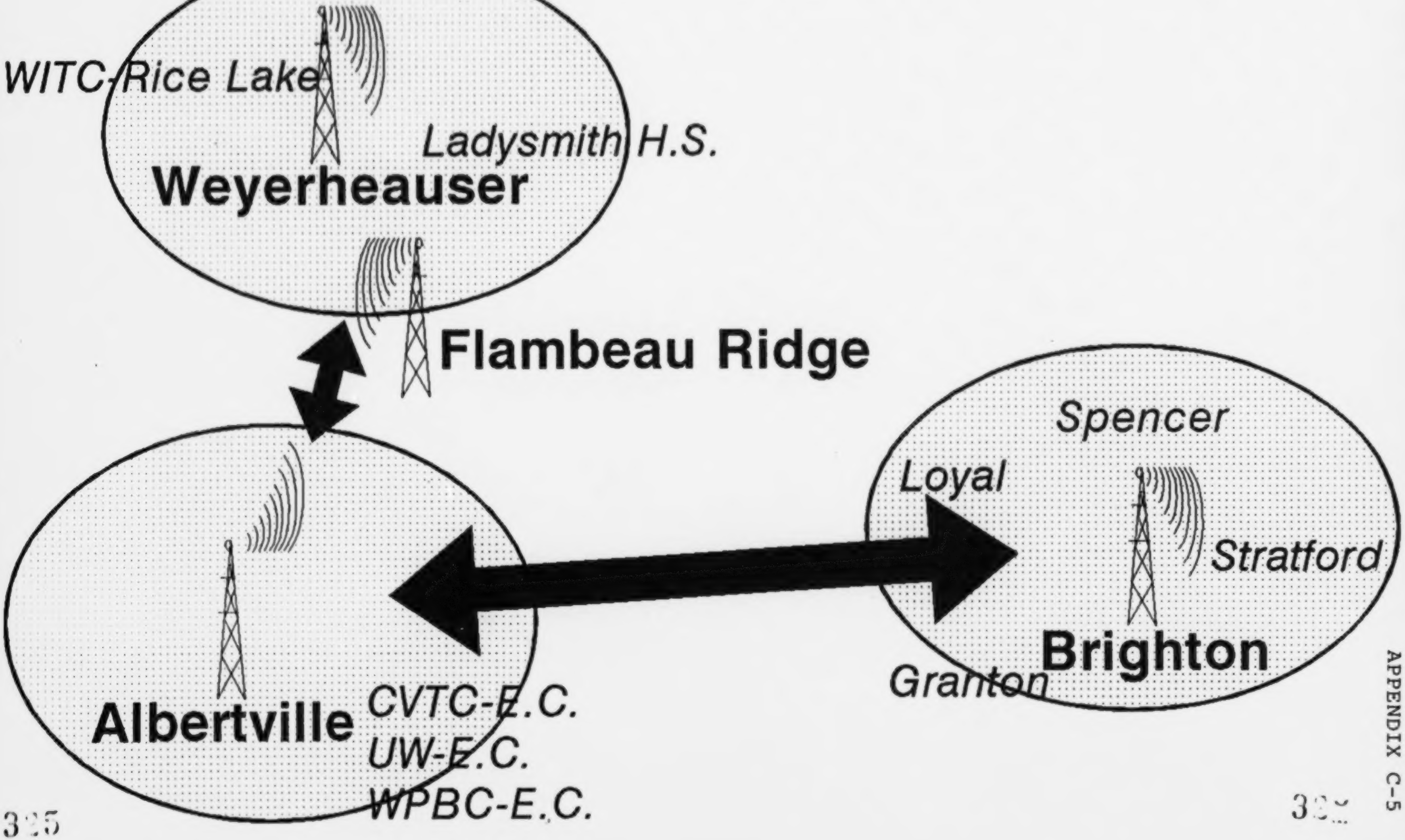
Last Revision: June 24, 1992

Rusk County/WIN Network Upgrades


WITC-Rice Lake
Flambeau H.S.
Bruce H.S.
Weyerheauser H.S.
Ladysmith H.S.
Flambeau Ridge
Lake Holcombe H.S.
Legend
STL Exists
New STL

APPENDIX C-4

Eau Claire ITFS, WIN Network and CWETN Linkages



WITC-Rice Lake

Ladysmith H.S.

Weyerheauser

Flambeau Ridge

Spencer

Loyal

Stratford

Brighton

Granton

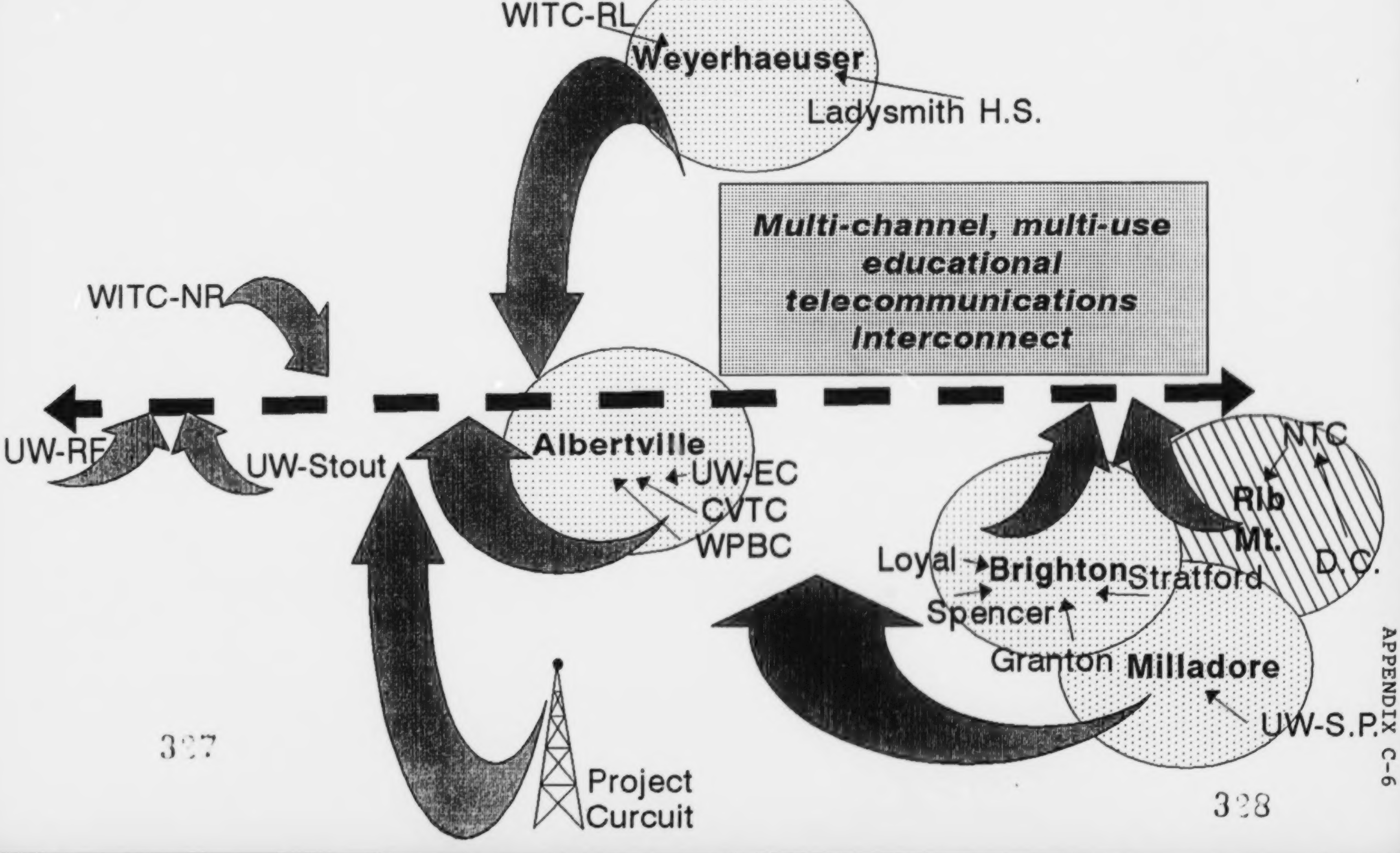
Albertville

CVTC-E.C.

UW-E.C.

WPBC-E.C.

A Conceptual Distance Education Communication Interconnect



WITC-RL

Weyerhaeuser

Ladysmith H.S.

Multi-channel, multi-use educational telecommunications Interconnect

WITC-NR

UW-RF

UW-Stout

Albertville

UW-EC

CVTC

WPBC

Project Curcuit

NTC

Rib Mt.

D.C.

Loyal

Brighton

Stratford

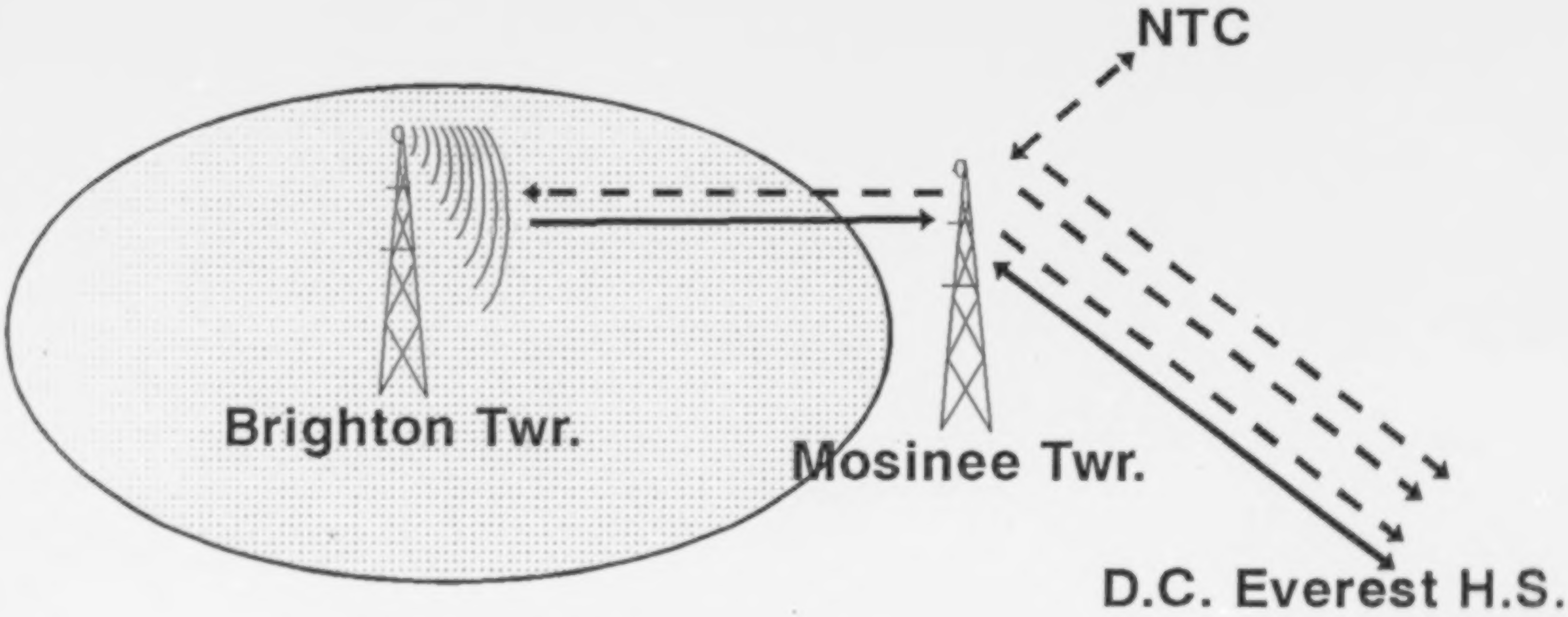
Spencer

Granton

Milladore

UW-S.P.

Enhancement of CWETN, D.C. Everest and NTC Linkages


NTC
Brighton Twr.
Mosinee Twr.
D.C. Everest H.S.

Western Wisconsin District Campuses

WESTERN WISCONSIN TECHNICAL COLLEGE

La Crosse Main Campus
304 North Sixth Street, La Crosse, WI 54602-0908
(608) 785-9200

Black River Falls Campus
720 Red Iron Road, Black River Falls, WI 54615
(715) 284-2253

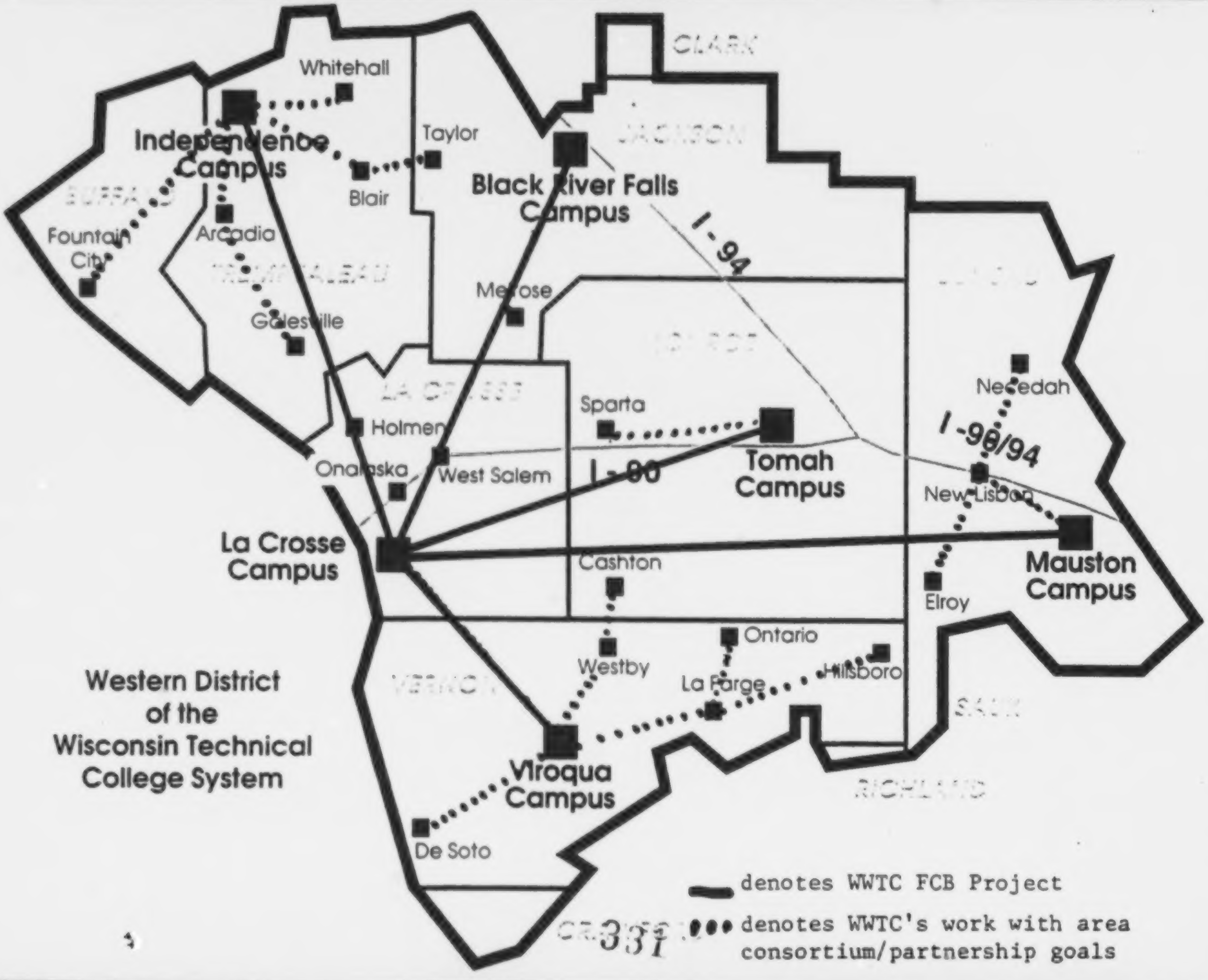
Independence Campus
204 Walnut Street, Independence, WI 54747
(715) 985-3392

Mauston Campus
211 Hickory Street, Mauston, WI 53948
(608) 847-7364

Tomah Campus
1310 Townline Road, Tomah, WI 54660
(608) 372-9292

Viroqua Campus
123 West Decker Street, Viroqua, WI 54665
(608) 637-2612

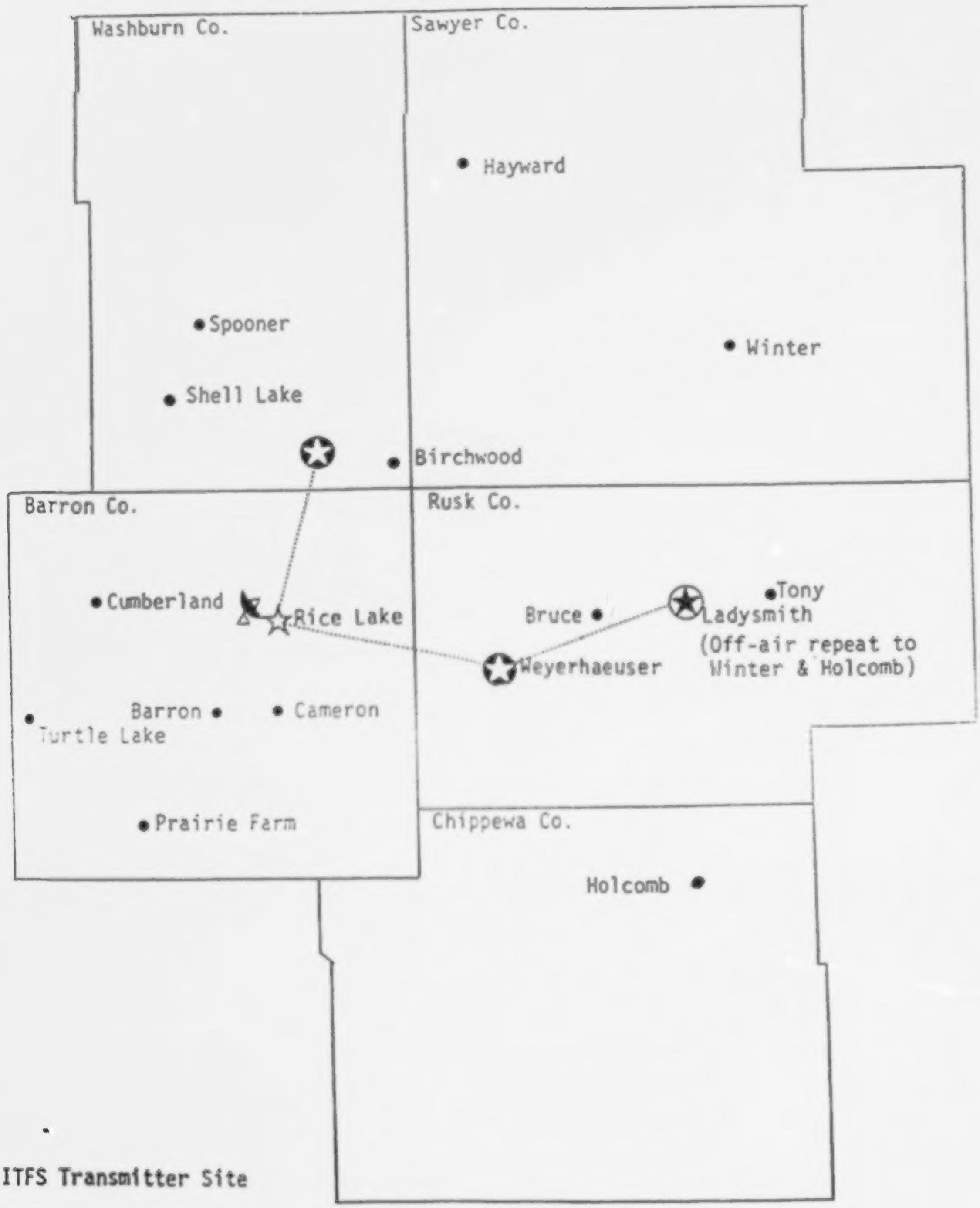
WISCONSIN
Western Wisconsin WTCS District
La Crosse


CLARK
JACKSON
BUFFALO
TREMPEALEAU
LA CROSSE
MONROE
JUNEAU
VERNON
SAUK
RICHLAND
CRAWFORD
Whitehall
Independence Campus
Taylor
Blair
Black River Falls Campus
Fountain City
Arcadia
Galesville
Melrose
I-94
Necedah
I-90/94
Sparta
Holmen
Onalaska
West Salem
I-90
Tomah Campus
New Lisbon
La Crosse Campus
Cashton
Mauston Campus
Elroy
Ontario
Westby
La Farge
Hillsboro
Viroqua Campus
De Soto

Western District of the Wisconsin Technical College System

— denotes WWTC FCB Project
••• denotes WWTC's work with area consortium/partnership goals

APPENDIX C-9


Washburn Co.
Sawyer Co.
Hayward
Spooner
Winter
Shell Lake
Birchwood
Barron Co.
Rusk Co.
Cumberland
Rice Lake
Bruce
Tony
Ladysmith
(Off-air repeat to Winter & Holcomb)
Weyerhaeuser
Barron
Cameron
Turtle Lake
Prairie Farm
Chippewa Co.
Holcomb

✪ ITFS Transmitter Site

☆ STL. Transmitter Site

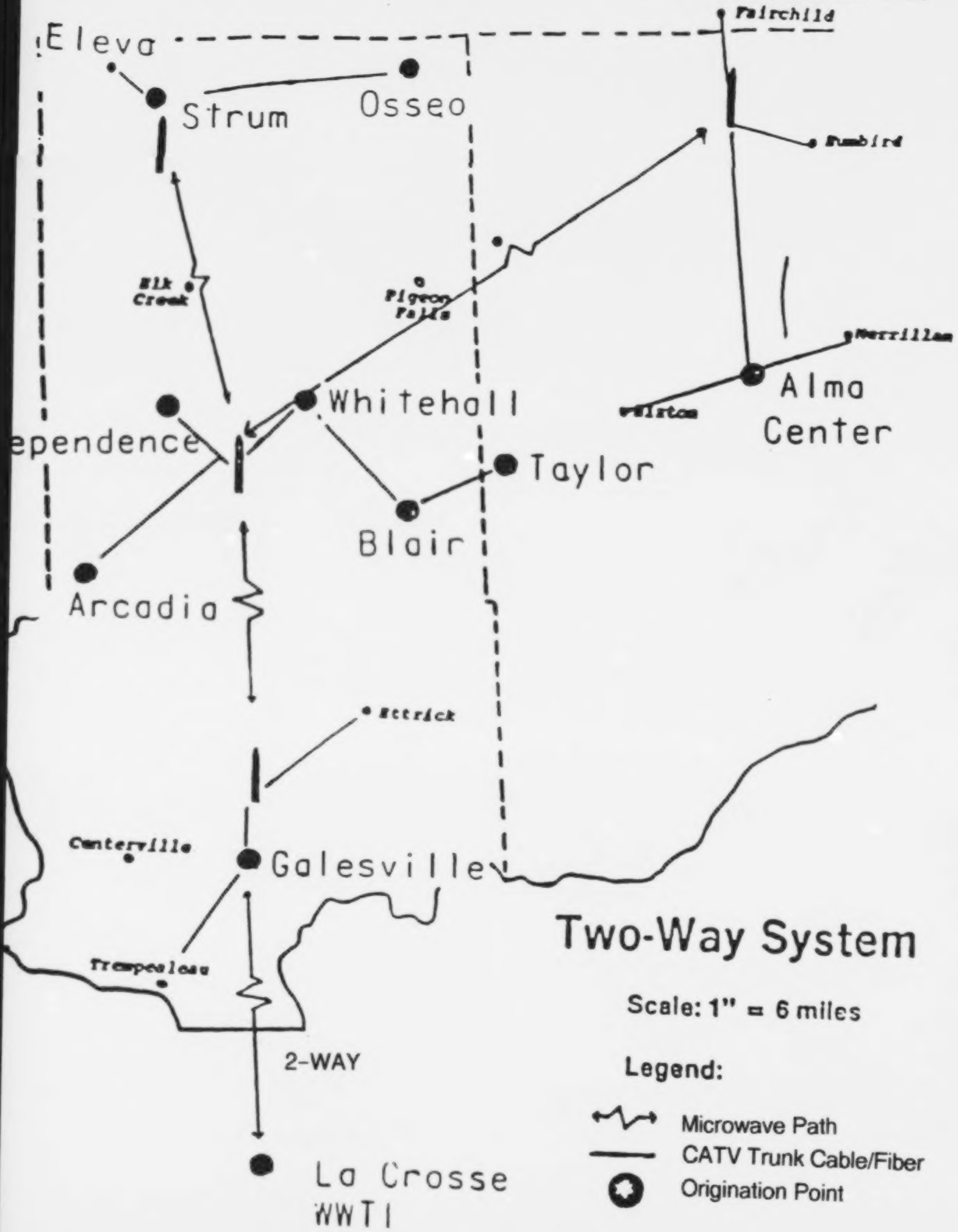
• Receive Site

SERC Receive Dish

— Studio to Transmitter Link (STL)

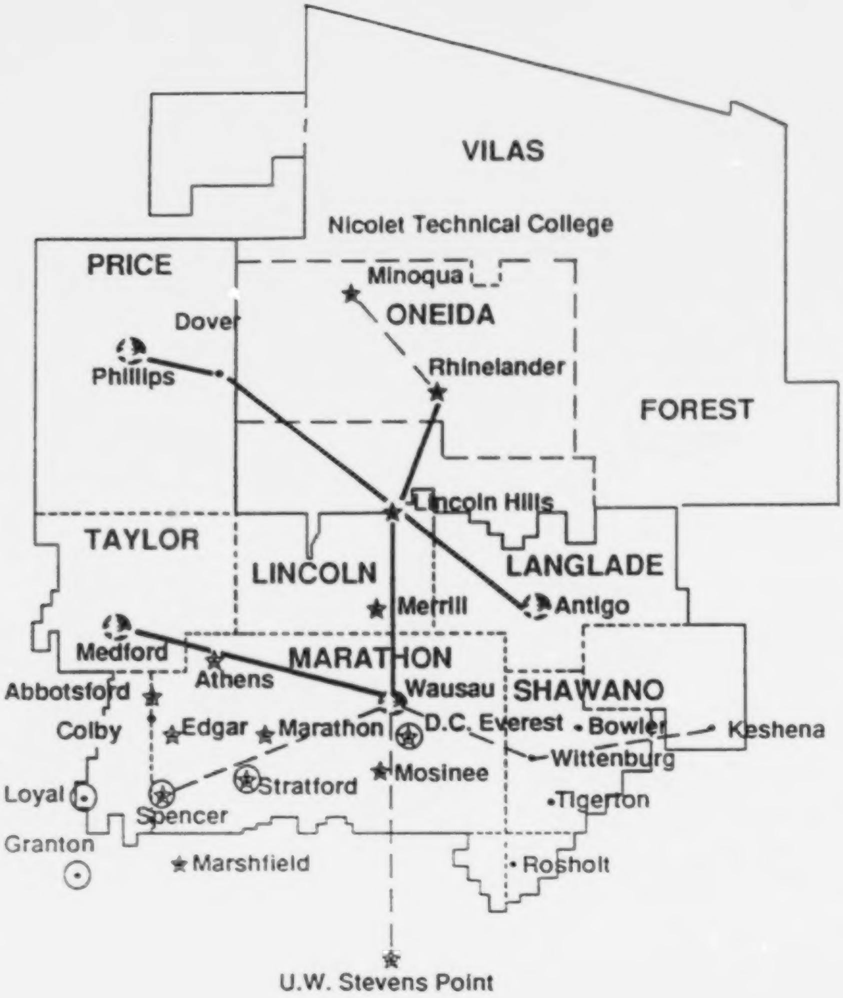
EDUCATIONAL DISTRIBUTION NETWORK

APPENDIX C-10


Fairchild
Eleva
Strum
Osseo
Humbird
Elk Creek
Pigeon Falls
Merrillan
Alma Center
Hixton
Whitehall
ependence
Taylor
Blair
Arcadia
Ettrick
Centerville
Galesville
Trempealeau
2-WAY
La Crosse WWTI
Two-Way System
Scale: 1" = 6 miles
Legend:
Microwave Path
CATV Trunk Cable/Fiber
Origination Point

APPENDIX C-11

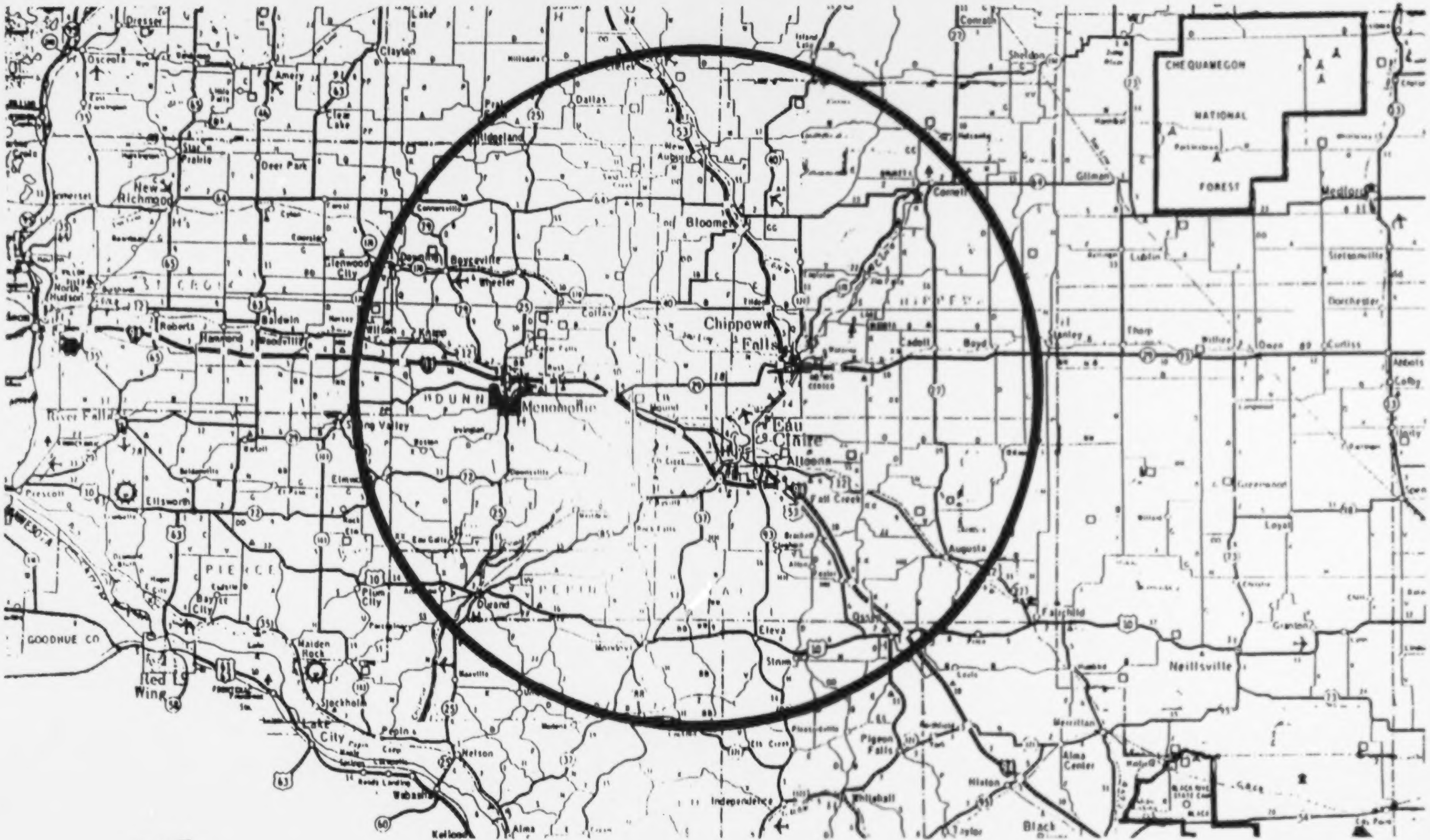
Northcentral Technical Telecommunications System


VILAS
Nicolet Technical College
PRICE
Minoqua
ONEIDA
Dover
Phillips
Rhinelander
FOREST
Lincoln Hills
TAYLOR
LINCOLN
LANGLADE
Merrill
Antigo
Medford
MARATHON
Athens
Abbotsford
Wausau
SHAWANO
Colby
Edgar
Marathon
D.C. Everest
Bowler
Keshena
Wittenburg
Loyal
Stratford
Mosinee
Tigerton
Spencer
Granton
Marshfield
Rosholt
U.W. Stevens Point

- NTC Campuses Receive both ITFS & Point to Point Microwave signals
- ☆ ITFS Receive Sites
- — NTC Point to Point Microwave System
- --- NTC Proposed Microwave System
  - 1990-91 Wittenburg
  - 1991-92 Spencer link
  - 1991092 Keshena link
- ○ Central Wisconsin Educational Telecommunications Network Loyal, Granton, Spencer, Stratford, and D.C. Everest

NORTHCENTRAL
TECHNICAL COLLEGE

Eau Claire Area ITFS System


Osceola
Dresser
Clayton
Amery
Clear Lake
Dallas
Ridgeland
New Auburn
Bloomer
Cornell
Gilman
CHEQUAMEGON
NATIONAL
FOREST
Medford
Stetsonville
Dorchester
Lublin
Sheldon
Conrath
New Richmond
Star Prairie
Deer Park
Glenwood City
Boyceville
Wheeler
Colfax
Chippewa Falls
Cadott
Boyd
Stanley
Thorp
Withee
Owen
Curtiss
Abbotsford
Colby
Roberts
Hammond
Baldwin
Woodville
Wilson
Knapp
DUNN
Menomonie
River Falls
Spring Valley
Eau Claire
Altoona
Prescott
Ellsworth
Elmwood
Fall Creek
Augusta
Greenwood
Loyal
PIERCE
PEPIN
Plum City
Bay City
Durand
Eleva
Strum
Osseo
Fairchild
Neillsville
Granton
GOODHUE CO
Red Wing
Maiden Rock
Stockholm
Pepin
Lake City
Nelson
Alma
Wabasha
Kellogg
Independence
Whitehall
Pigeon Falls
Merrillan
Alma Center
Hixton
Black River Falls

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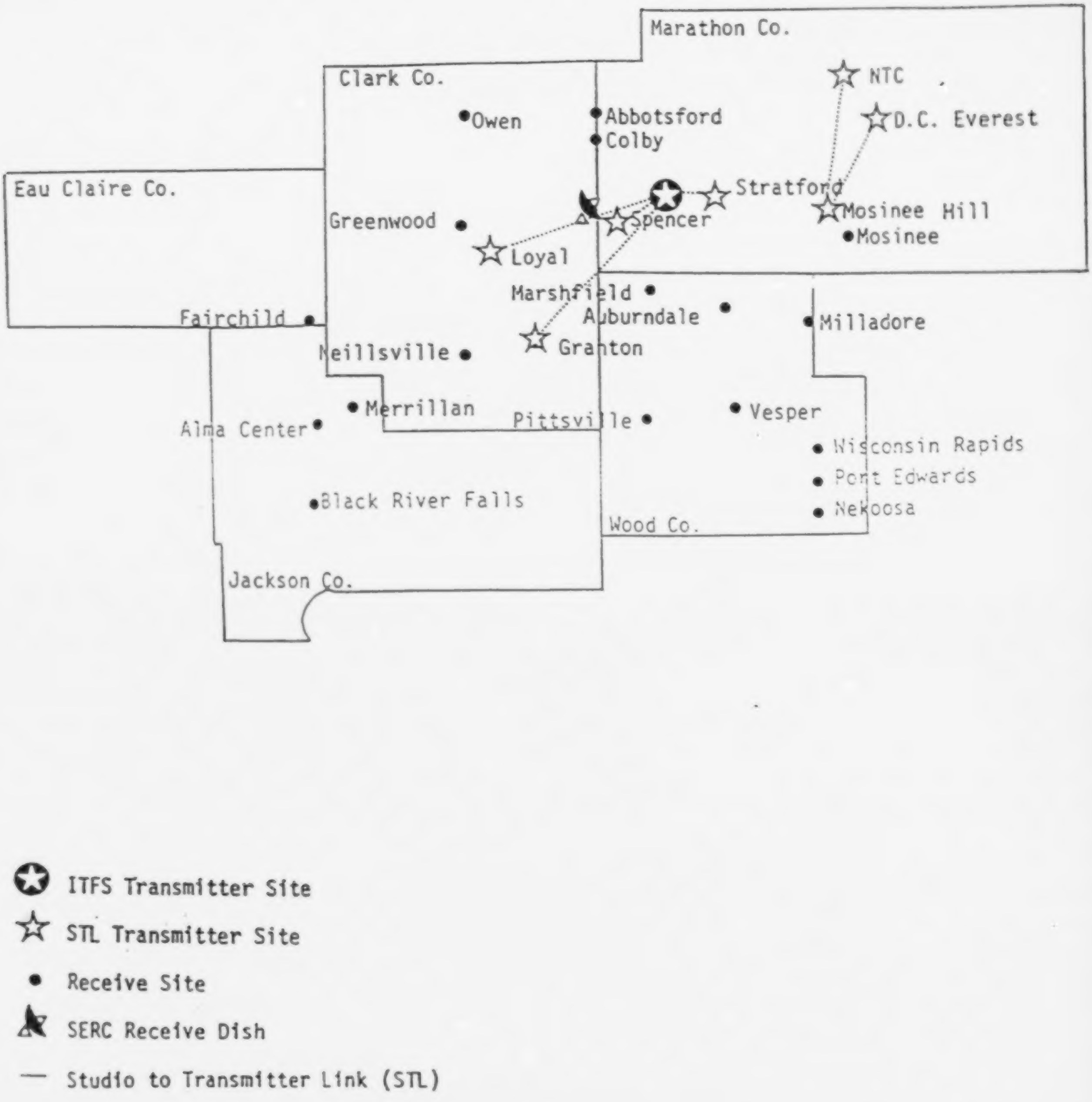
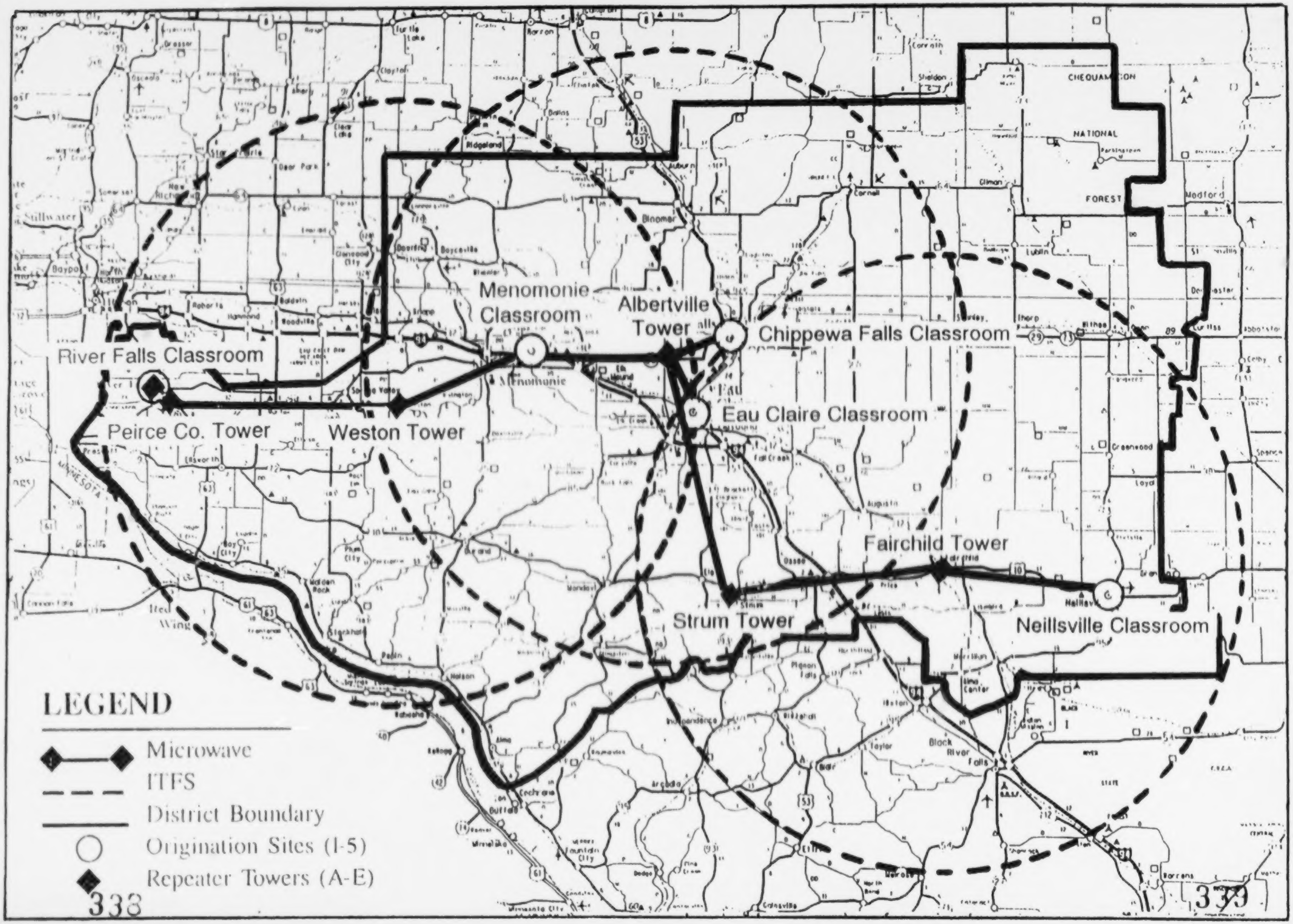
APPENDIX C-13


Marathon Co.
Clark Co.
Eau Claire Co.
Jackson Co.
Wood Co.
NTC
D.C. Everest
Owen
Abbotsford
Colby
Stratford
Mosinee Hill
Mosinee
Greenwood
Spencer
Loyal
Marshfield
Auburndale
Milladore
Fairchild
Neillsville
Granton
Merrillan
Alma Center
Pittsville
Vesper
Wisconsin Rapids
Port Edwards
Nekoosa
Black River Falls
✪ ITFS Transmitter Site
☆ STL Transmitter Site
● Receive Site
SERC Receive Dish
— Studio to Transmitter Link (STL)

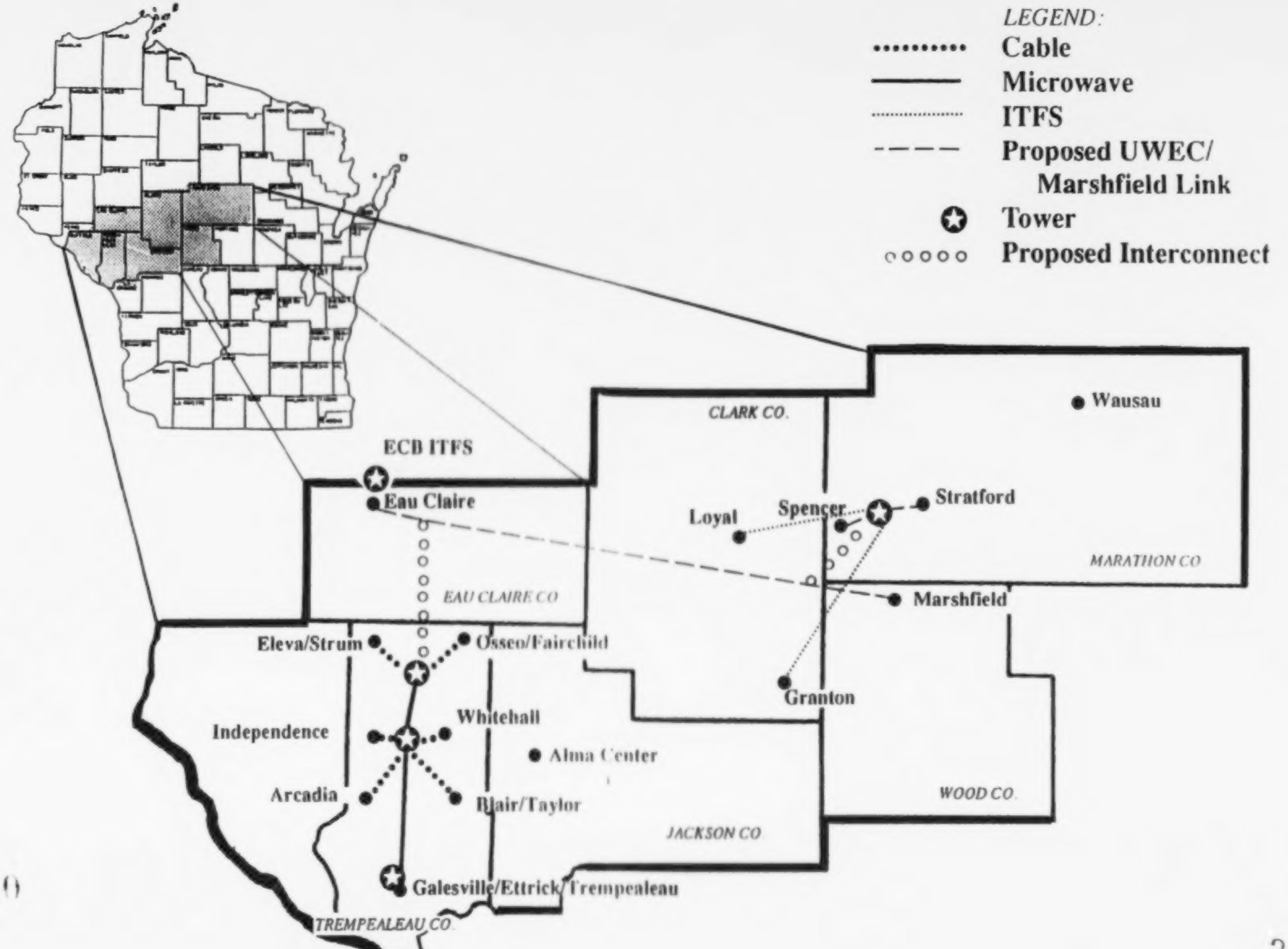
Chippewa Valley Technical College

ITV/ITFS System

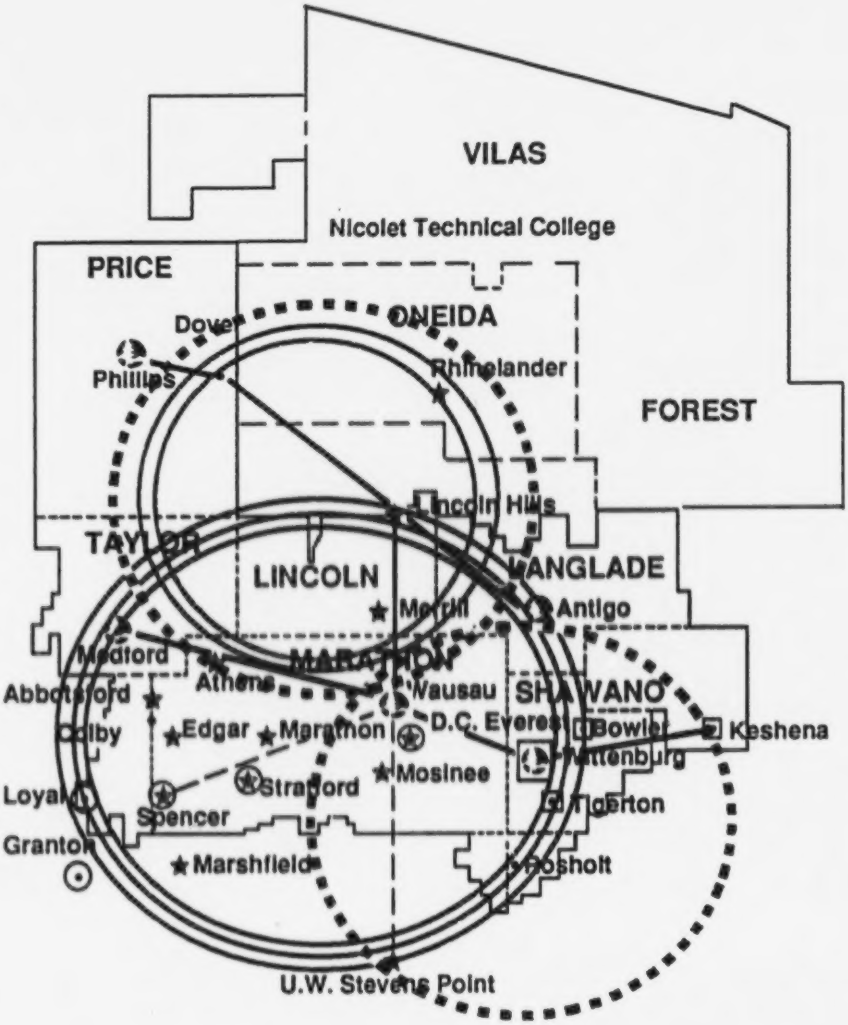

Menomonie Classroom
Albertville Tower
Chippewa Falls Classroom
River Falls Classroom
Eau Claire Classroom
Peirce Co. Tower
Weston Tower
Fairchild Tower
Strum Tower
Neillsville Classroom
CHEQUAMEGON NATIONAL FOREST
Medford
Stillwater
Red Wing
Black River Falls
Menomonie
LEGEND
Microwave
ITFS
District Boundary
Origination Sites (1-5)
Repeater Towers (A-E)

APPENDIX C-14

UW-Eau Claire, Saint Joseph's Hospital, Trempealeau County, CWETN Interconnect


LEGEND:
Cable
Microwave
ITFS
Proposed UWEC/ Marshfield Link
Tower
Proposed Interconnect
ECB ITFS
Eau Claire
EAU CLAIRE CO
CLARK CO.
Wausau
Loyal
Spencer
Stratford
MARATHON CO
Marshfield
Eleva/Strum
Osseo/Fairchild
Granton
Independence
Whitehall
Alma Center
Arcadia
Blair/Taylor
WOOD CO.
JACKSON CO
Galesville/Ettrick/Trempealeau
TREMPEALEAU CO.

APPENDIX C-16


VILAS
Nicolet Technical College
PRICE
ONEIDA
Dover
Phillips
Rhinelander
FOREST
Lincoln Hills
TAYLOR
LINCOLN
LANGLADE
Merrill
Antigo
Medford
MARATHON
Athens
Abbotsford
Wausau
SHAWANO
Colby
Edgar
Marathon
D.C. Everest
Bowler
Keshena
Wittenburg
Mosinee
Loyal
Stratford
Spencer
Tigerton
Granton
Marshfield
Rosholt
U.W. Stevens Point

NTC Campuses
Receive both ITFS & Point to Point Microwave signals

○ **3 ITFS Channels licensed by WECB**

○ **2 ITFS Channels licensed by NTC**

○ **2 ITFS Channels proposed for construction**

★ **ITFS Receive Sites**

— **NTC Point to Point Microwave System**

--- **NTC Proposed Microwave System**
1992- Keshena link
1993- Spencer link

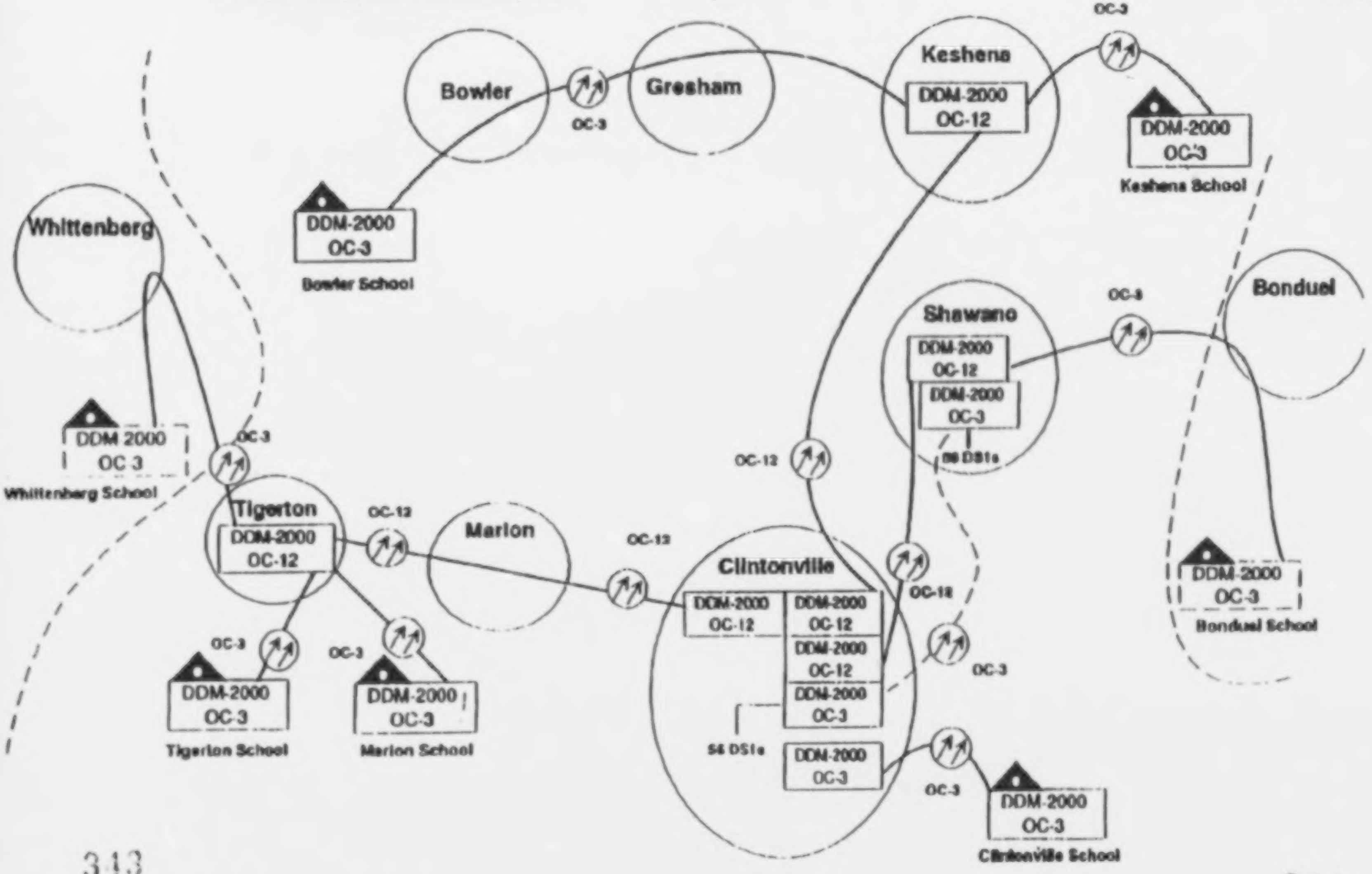
○ **Central Wisconsin Educational Telecommunications Network**
Loyal, Granton, Spencer, Stratford, and D.C. Everest

☐ **Embarass River Institutional Network Grou**
Erving,Tigerton, Clintonville,Marion, Bonduel, Wittenburg, Memomonie Indian Reservation

W.A.N.U.C.
Chair - Barbara Cummings
Northcentral Technical College
1000 Campus Drive • Wausau, WI 54401-1899
Ph. *(715) 675-3331, ext. 340*

Urban Telephone Company **PHASE II**

AT&T Proposal No. GC-91-033673-1
March, 1991


OC-3
Keshena
DDM-2000
OC-12
Bowler
Gresham
OC-3
DDM-2000
OC-3
Keshena School
DDM-2000
OC-3
Bowler School
Whittenberg
Bonduel
OC-3
Shawano
DDM-2000
OC-12
DDM-2000
OC-3
56 DS1s
DDM 2000
OC 3
Whittenberg School
OC-3
OC-12
Tigerton
DDM-2000
OC-12
OC-12
Marion
OC-12
Clintonville
DDM-2000
OC-12
DDM-2000
OC-12
DDM-2000
OC-12
DDM-2000
OC-3
OC-12
DDM-2000
OC-3
Bonduel School
OC-3
OC-3
OC-3
DDM-2000
OC-3
DDM-2000
OC-3
Tigerton School
Marion School
56 DS1s
DDM-2000
OC-3
OC-3
DDM-2000
OC-3
Clintonville School

343

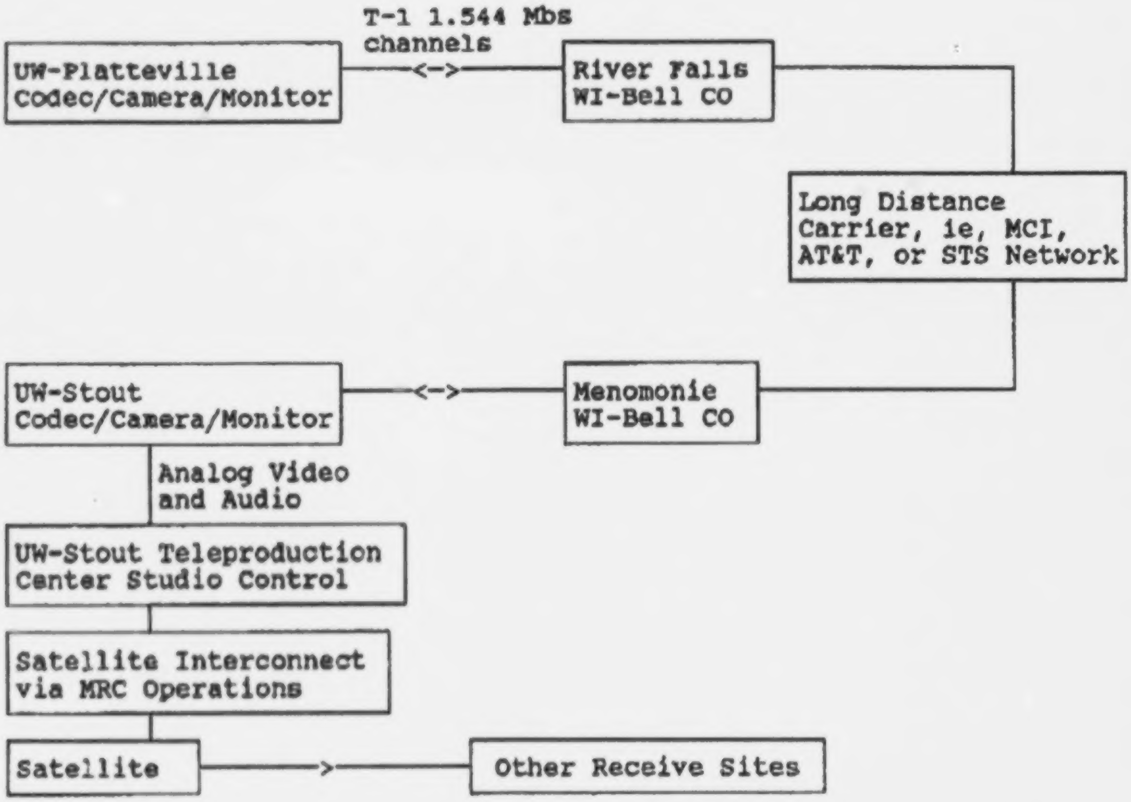
344

Figure 2

fkp: 3-91

APPENDIX C-18

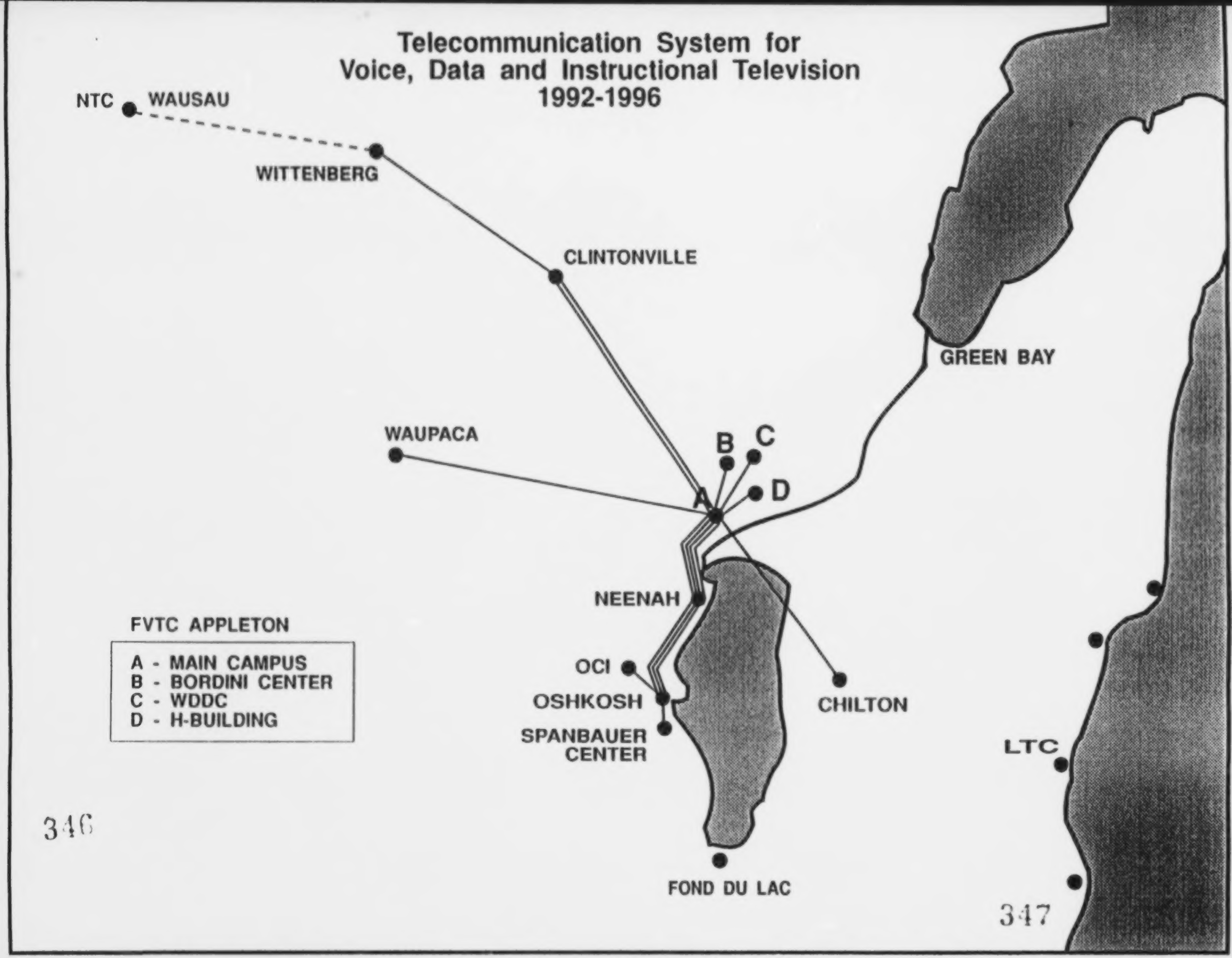
UW-Stout/UW-Platteville Interactive Video


T-1 1.544 Mbs channels
UW-Platteville Codec/Camera/Monitor
<->
River Falls WI-Bell CO
Long Distance Carrier, ie, MCI, AT&T, or STS Network
UW-Stout Codec/Camera/Monitor
<->
Menomonie WI-Bell CO
Analog Video and Audio
UW-Stout Teleproduction Center Studio Control
Satellite Interconnect via MRC Operations
Satellite
>
Other Receive Sites

The proposed system woud be a simple T-1 interconnect between the two university campus television operations. T-1 codecs at each location would provide the necessary analog interface to cameras and monitors and/or the microwave to the uplink facility.

Any site, including UW-Stout would have the capability of utilizing the satellite interconnection which already exists at UW-Stout. The quality would be no less that that produced via T-1 Compressed Video . Return audio would be handled via a telephone line.

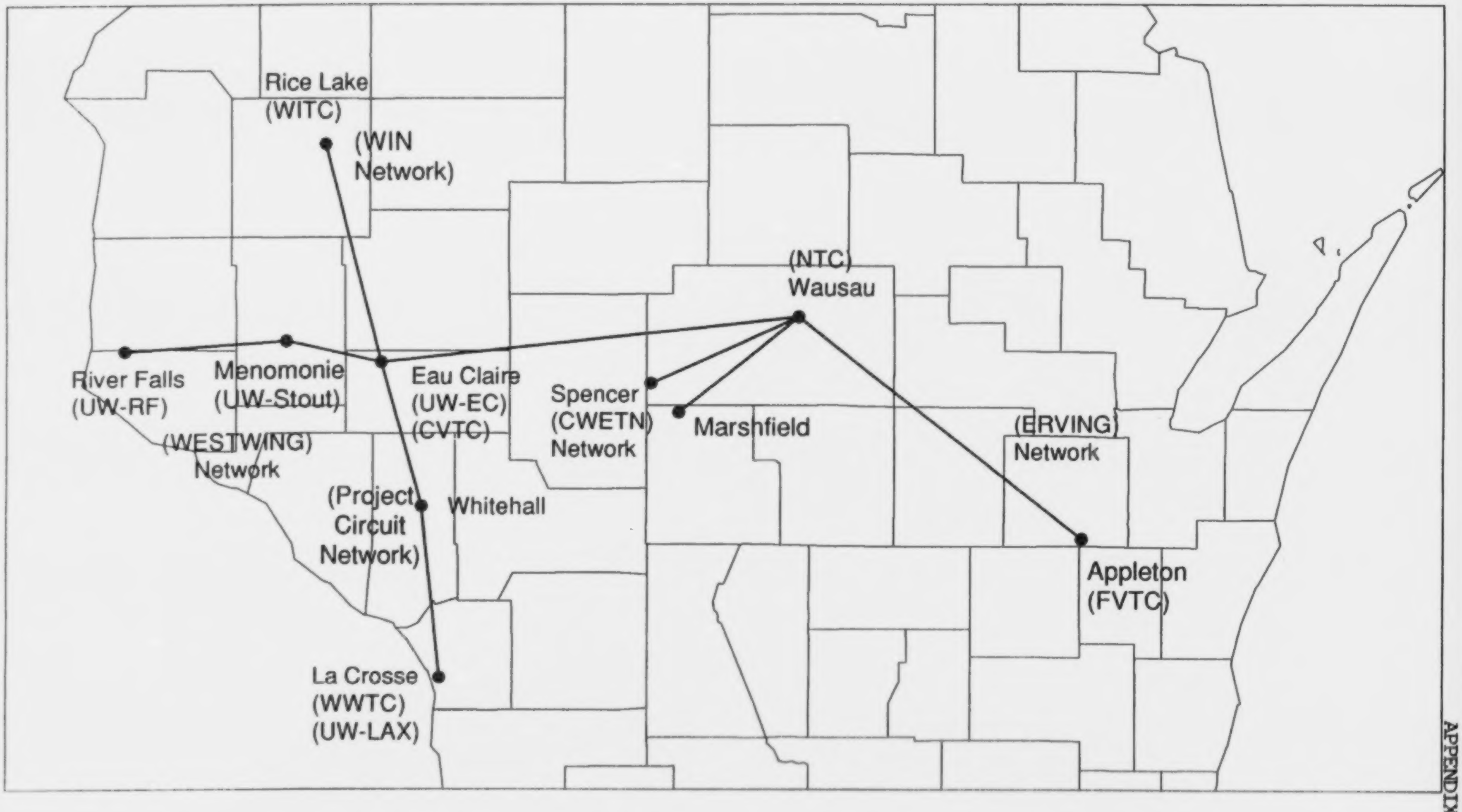
In addition to the above options, as connects become available to cable systems, ITFS transmitter systems, etc., the analog interface of a codec can be interconnected.



Telecommunication System for Voice, Data and Instructional Television 1992-1996

NTC
WAUSAU
WITTENBERG
CLINTONVILLE
GREEN BAY
WAUPACA
B
C
A
D
NEENAH
OCI
OSHKOSH
SPANBAUER CENTER
CHILTON
LTC
FOND DU LAC
FVTC APPLETON
A - MAIN CAMPUS
B - BORDINI CENTER
C - WDDC
D - H-BUILDING

WEST CENTRAL PLANNING GROUP
CONCEPTUAL NETWORK DIAGRAM - PHASE I


Rice Lake
(WITC)
(WIN
Network)
(NTC)
Wausau
River Falls
(UW-RF)
Menomonie
(UW-Stout)
Eau Claire
(UW-EC)
(CVTC)
Spencer
(CWETN)
Network
Marshfield
(ERVING)
Network
(WESTWING)
Network
(Project
Circuit
Network)
Whitehall
Appleton
(FVTC)
La Crosse
(WWTC)
(UW-LAX)

343

349

EVANS ASSOCIATES 2/93

EXISTING FIBER

APPENDIX D-1

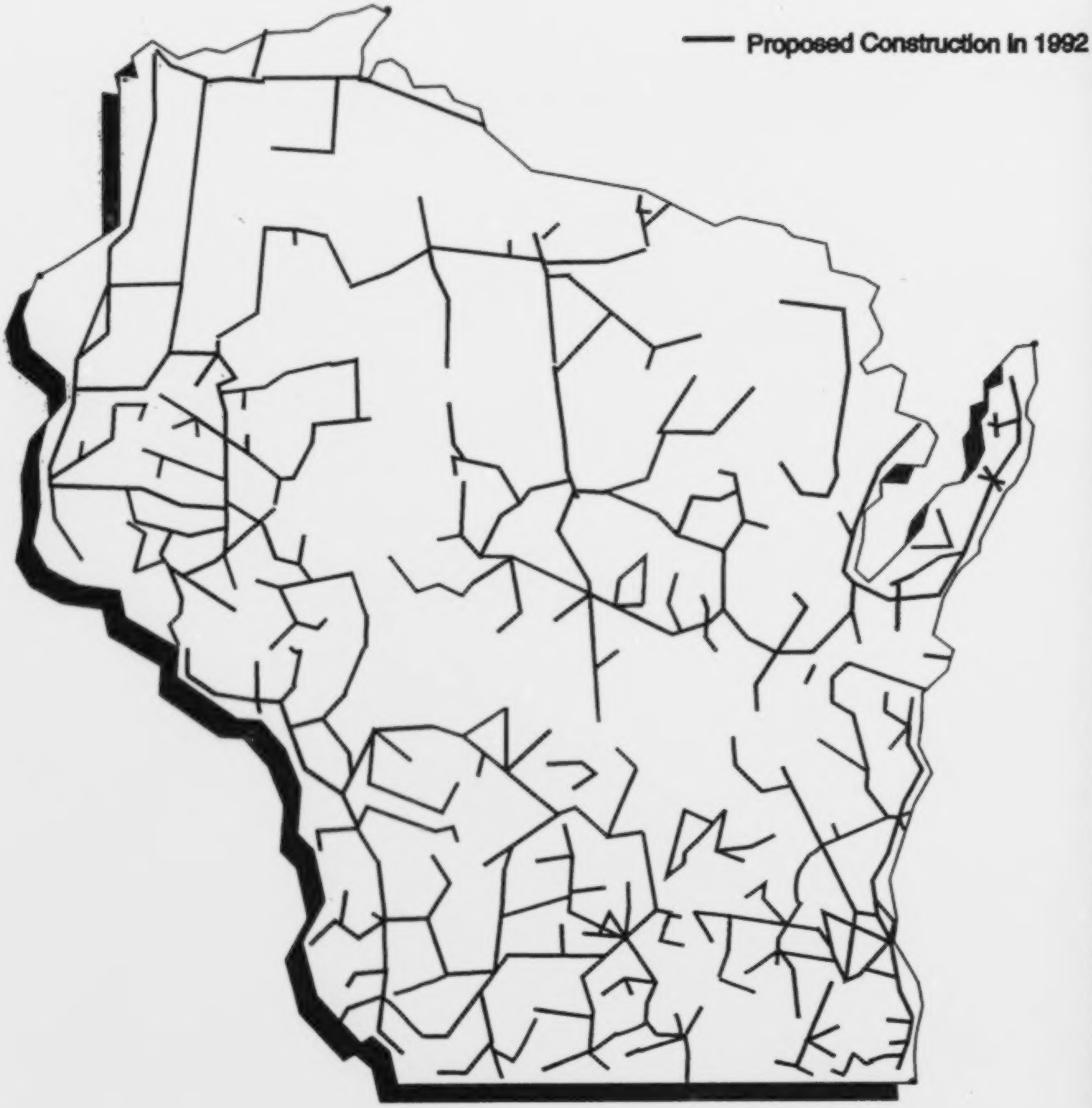
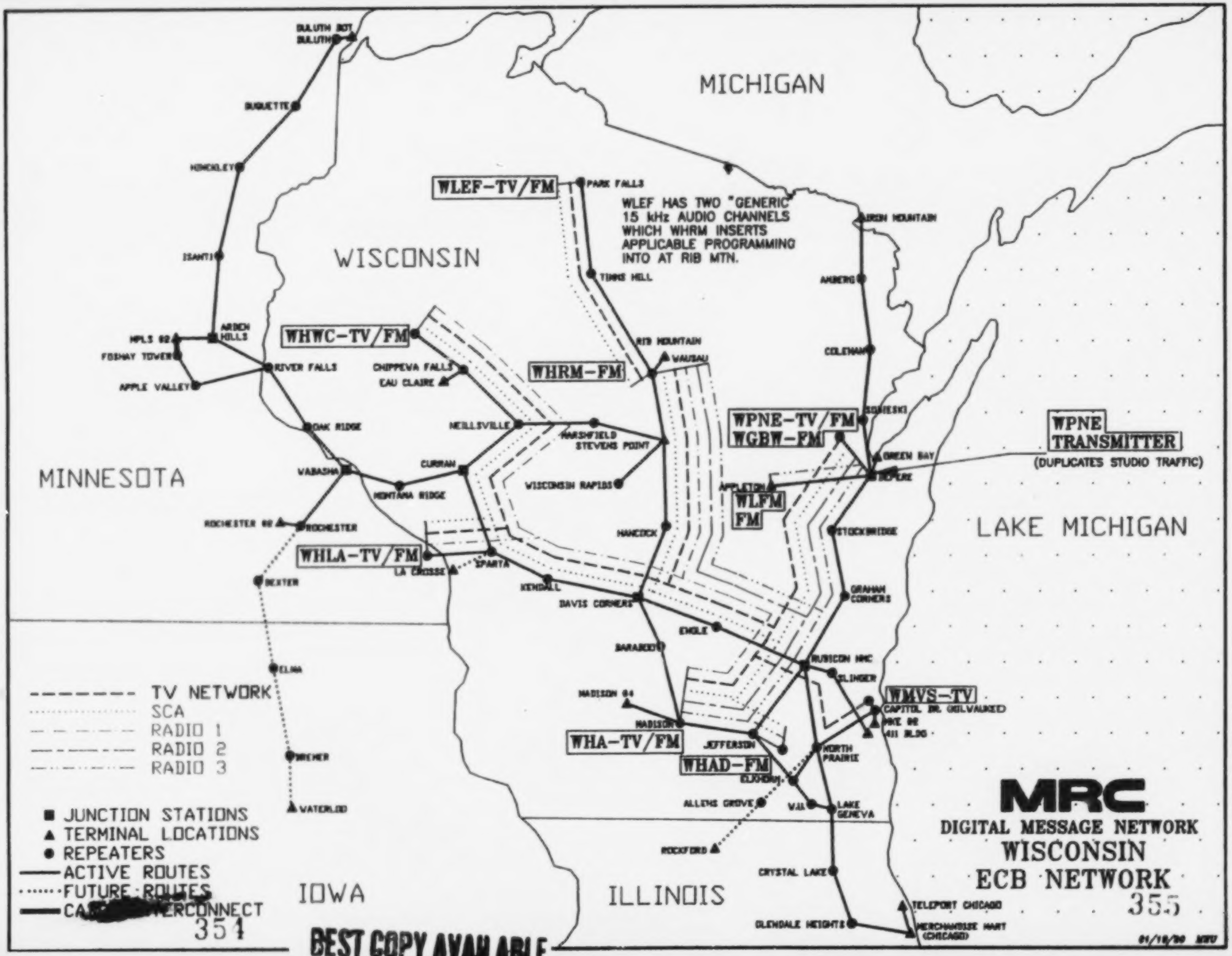

— Proposed Construction In 1992

Table 1: Route Miles – Interexchange Carriers

	Route-Miles						
Calendar Year:	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
AT&T	*5,677*	*10,893*	*18,000*	*23,324*	*28,900*	*32,398*	*36,871*
Electra	*382*	*382*	*382*	*382*	*382*	*493*	*493*
Mutual Signal Corp.	*NA*	*NA*	*421*	*421*	*421*	*421*	*421*
CTI (Electra + Mutual)	*382*	*382*	*803*	*803*	*803*	*914*	*914*
Diginet	*NA*	*NA*	*NA*	*90*	*90*	*90*	*90*
MCI	*3,025*	*6,752*	*10,267*	*12,467*	*13,839*	*17,600*	*19,793*
MRC Telecommunications	*NA*	*NA*	*670*	*670*	*844*	*844*	*844*
ATC	*800*	*950*	*967*	*1,127*	*1,163*	*1,163*	*1,163*
Consolidated Network	*310*	*310*	*352*	*352*	*352*	*352*	*352*
Litel	*881*	*950*	*1,210*	*1,210*	*1,210*	*1,210*	*1,406*
RCI	*580*	*580*	*796*	*413*	*414*	*415*	*417*
Williams Telecom.	*3,084*	*7,936*	*8,202*	*9,135*	*9,725*	*9,893*	*9,930*
NTN Total	*5,655*	*10,726*	*11,527*	*12,237*	*12,864*	*13,033*	*13,268*
US Sprint	*5,300*	*11,915*	*17,476*	*21,938*	*22,002*	*22,093*	*22,725*
Valley Net	*NA*	*NA*	*NA*	*NA*	*520*	*570*	*581*
Total Reported:	*20,039*	*40,668*	*58,743*	*71,529*	*79,862*	*87,542*	*95,086*

Table 6: Fiber Deployment by Local Operating Companies

			Fiber-Miles				
Company	1985	1986	1987	1988	1989	1990	1991
Ameritech	77,700	111,100	147,100	177,500	228,400	285,500	388,900
Bell Atlantic	83,085	150,847	227,507	311,022	373,398	522,970	801,960
BellSouth	50,807	170,092	218,489	319,248	445,452	591,938	734,054
NYNEX	83,384	129,743	207,077	290,600	357,766	473,274	636,954
Pacific Telesis	84,310	97,800	101,090	110,273	126,944	189,077	253,359
Southwestern Bell	70,490	151,043	182,911	214,948	270,300	352,300	453,000
US West	47,341	70,082	107,782	163,968	234,851	351,571	542,308
Regional Bell Totals:	497,117	880,707	1,191,956	1,587,559	2,037,111	2,766,630	3,810,535
Contel Companies						103,603	106,035
GTE Companies				134,677	163,396	213,891	254,720
United Companies				32,287	54,569	87,591	122,525
Rural Companies		2,000	14,236	28,705	42,260	68,237	NA
Total Reported:	497,117	882,707	1,206,192	1,783,228	2,297,336	3,239,952	4,293,815


MICHIGAN
WISCONSIN
MINNESOTA
LAKE MICHIGAN
IOWA
ILLINOIS
DULUTH BOT
DULUTH
DUQUETTE
HINCKLEY
ISANTI
ARDEN HILLS
MPLS 82
FOSHAY TOWER
APPLE VALLEY
RIVER FALLS
OAK RIDGE
WABASHA
MONTANA RIDGE
ROCHESTER 82
ROCHESTER
DEXTER
ELMA
BREMER
WATERLOO
WLEF-TV/FM
PARK FALLS
TIMMS HILL
WHWC-TV/FM
CHIPPEWA FALLS
EAU CLAIRE
NEILLSVILLE
MARSHFIELD
STEVENS POINT
WISCONSIN RAPIDS
CURRAN
WHLA-TV/FM
LA CROSSE
SPARTA
KENDALL
DAVIS CORNERS
WHRM-FM
RIB MOUNTAIN
WAUSAU
HANCOCK
BARABOO
ENGLE
MADISON 04
MADISON
WHA-TV/FM
JEFFERSON
WHAD-FM
ELKHORN
ALLENS GROVE
ROCKFORD
VAIL
LAKE GENEVA
NORTH PRAIRIE
CRYSTAL LAKE
GLENDALE HEIGHTS
TELEPORT CHICAGO
MERCHANDISE MART (CHICAGO)
IRON MOUNTAIN
AMBERG
COLEMAN
SOBIESKI
WPNE-TV/FM
WGBW-FM
GREEN BAY
DEPERE
APPLETON
WLFM FM
STOCKBRIDGE
GRAHAM CORNERS
RUBICON MRC
SLINGER
WMVS-TV
CAPITOL DR. (MILWAUKEE)
MKE 88
411 BLDG
WPNE TRANSMITTER
(DUPLICATES STUDIO TRAFFIC)
WLEF HAS TWO "GENERIC" 15 kHz AUDIO CHANNELS WHICH WHRM INSERTS APPLICABLE PROGRAMMING INTO AT RIB MTN.
TV NETWORK
SCA
RADIO 1
RADIO 2
RADIO 3
■ JUNCTION STATIONS
▲ TERMINAL LOCATIONS
● REPEATERS
ACTIVE ROUTES
FUTURE ROUTES
CA[redacted]ERCONNECT
01/10/90 MRU

MRC

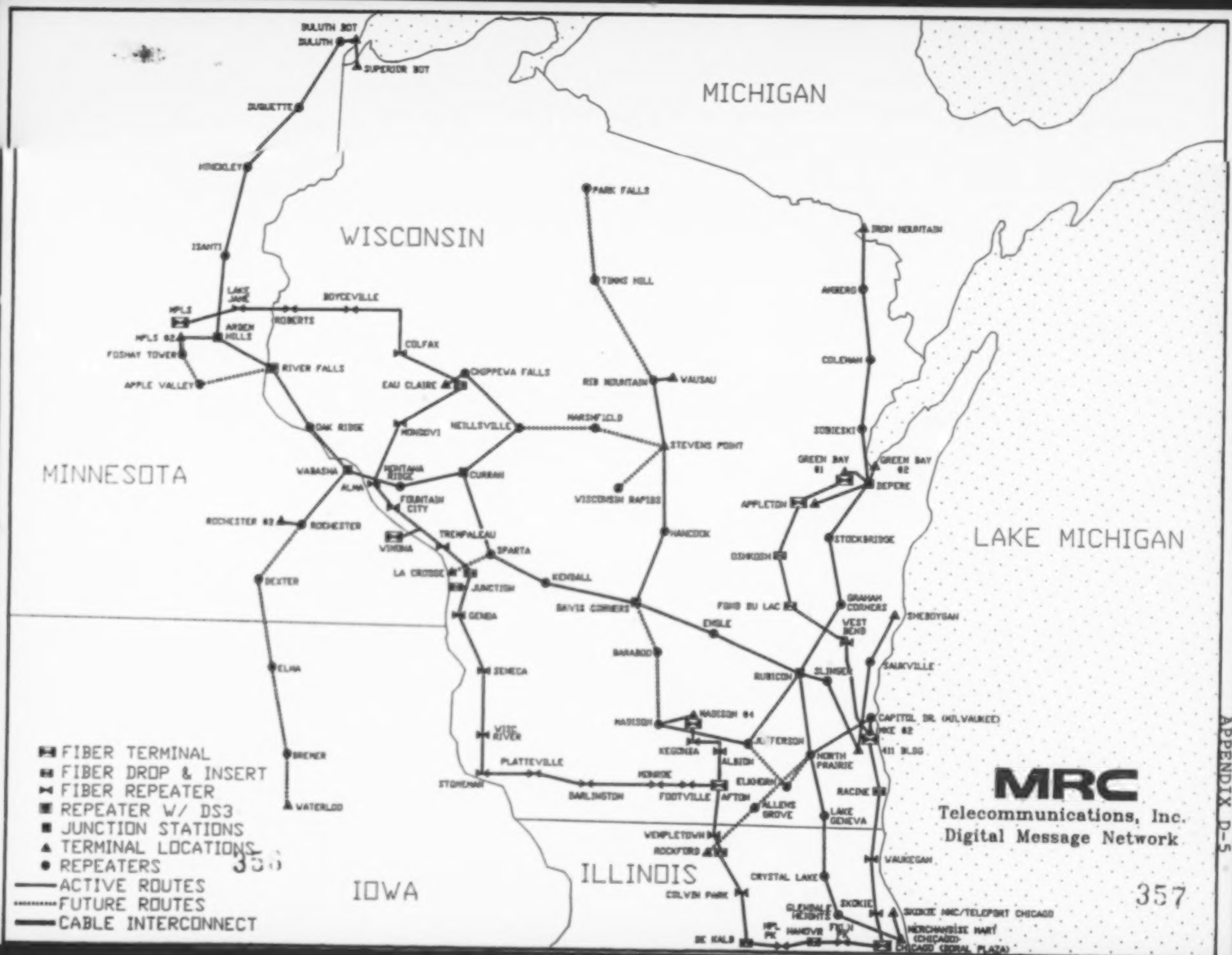
DIGITAL MESSAGE NETWORK

WISCONSIN

ECB NETWORK

APPENDIX D-4

BEST COPY AVAILABLE

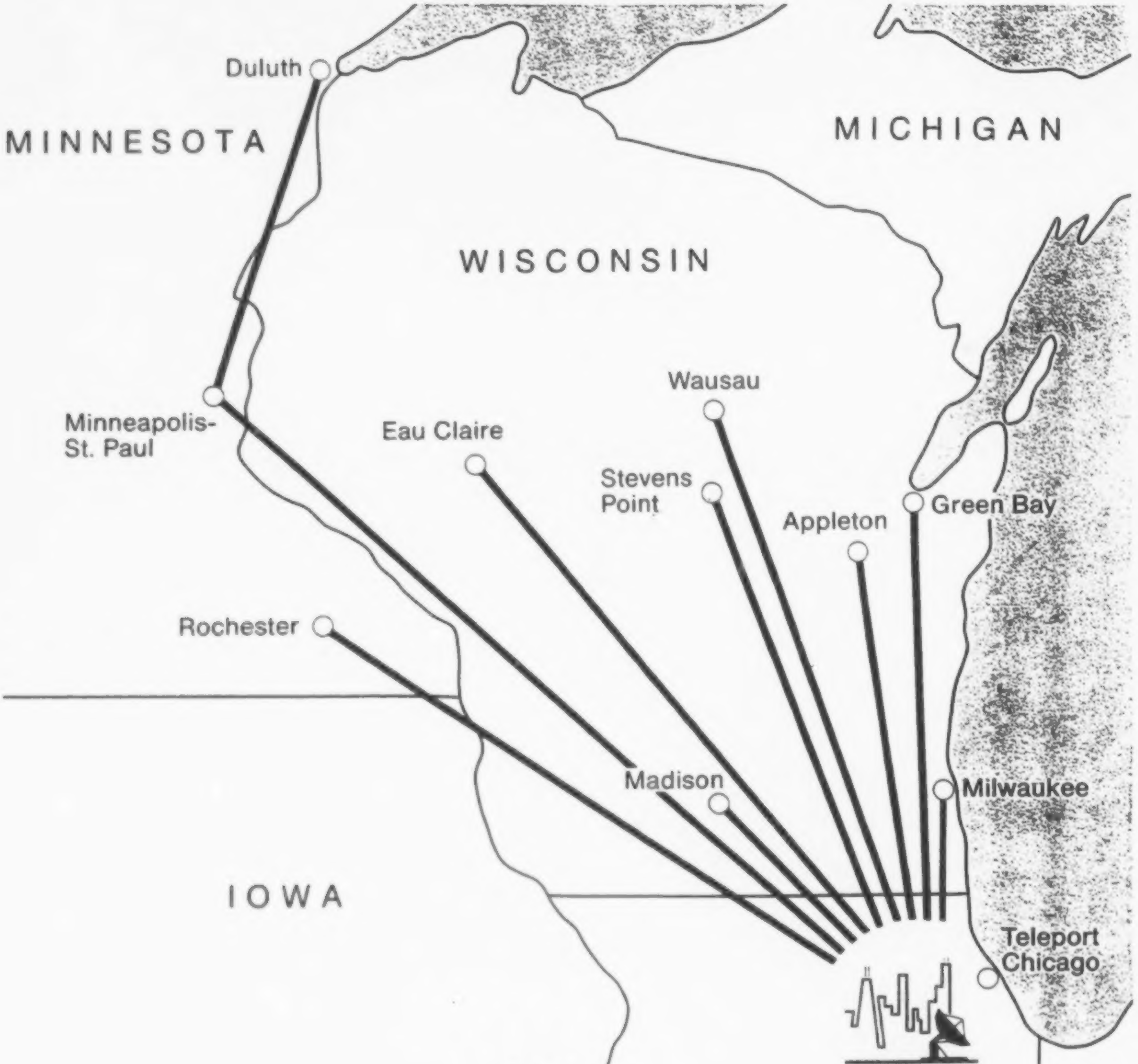

DULUTH BOT
DULUTH
SUPERIOR BOT
DUQUETTE
HINCKLEY
ISANTI
LAKE JANE
MPLS
MPLS 02
ARDEN HILLS
FOSHAY TOWER
APPLE VALLEY
ROBERTS
BOYCEVILLE
COLFAX
RIVER FALLS
CHIPPEWA FALLS
EAU CLAIRE
MONDOVI
OAK RIDGE
NEILLSVILLE
MARSHFIELD
WABASHA
ALMA
MONTANA RIDGE
CURRAN
FOUNTAIN CITY
ROCHESTER 02
ROCHESTER
VIRGINA
TREMPALEAU
SPARTA
LA CROSSE
JUNCTION
DEXTER
GENOA
SENECA
ELMA
VISC RIVER
BREMER
WATERLOO
STONEMAN
PLATTEVILLE
DARLINGTON
MONROE
FOOTVILLE
AFTON
KENDALL
DAVIS CORNERS
BARABOO
MADISON
MADISON 04
KEGONSA
ALBION
JEFFERSON
ELKHORN
ALLENS GROVE
WEMPLETOWN
ROCKFORD
COLVIN PARK
DE KALB
NPL PK
HANOVR
FKLN PK
PARK FALLS
TIMMS HILL
RIB MOUNTAIN
WAUSAU
STEVENS POINT
WISCONSIN RAPIDS
HANCOCK
IRON MOUNTAIN
AMBERG
COLEMAN
SOBIESKI
GREEN BAY 01
GREEN BAY 02
DEPERE
APPLETON
STOCKBRIDGE
OSHKOSH
FOND DU LAC
GRAHAM CORNERS
WEST BEND
SHEBOYGAN
SAUKVILLE
EDGLE
RUBICON
SLINGER
CAPITOL DR. (MILWAUKEE)
MKE 02
411 BLDG
NORTH PRAIRIE
RACINE
LAKE GENEVA
WAUKEGAN
CRYSTAL LAKE
GLENDALE HEIGHTS
SKOKIE
SKOKIE MRC/TELEPORT CHICAGO
MERCHANDISE MART (CHICAGO)
CHICAGO (CORAL PLAZA)
MICHIGAN
WISCONSIN
MINNESOTA
LAKE MICHIGAN
IOWA
ILLINOIS
⧓ FIBER TERMINAL
▪ FIBER DROP & INSERT
⋈ FIBER REPEATER
▣ REPEATER W/ DS3
■ JUNCTION STATIONS
▲ TERMINAL LOCATIONS
● REPEATERS
——ACTIVE ROUTES
·········FUTURE ROUTES
━━CABLE INTERCONNECT

MRC
Telecommunications, Inc.
Digital Message Network

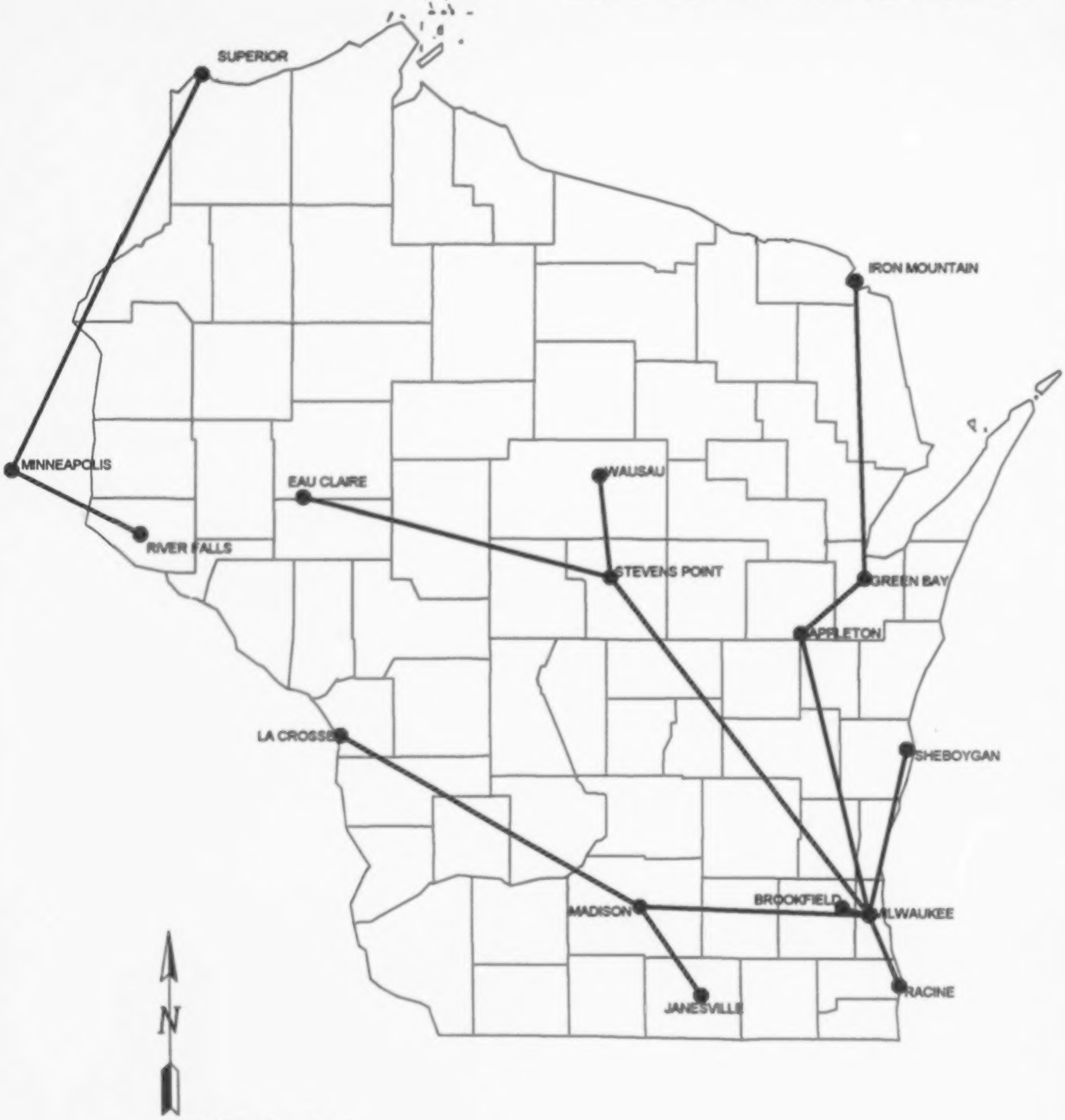
APPENDIX D-6

ACCESS TO UPLINK FACILITIES THROUGH MRC

Toll-Free Regional Access to Teleport Chicago


Duluth
MINNESOTA
MICHIGAN
WISCONSIN
Wausau
Minneapolis-St. Paul
Eau Claire
Stevens Point
Appleton
Green Bay
Rochester
Madison
Milwaukee
IOWA
Teleport Chicago
TELEPORT CHICAGO
ILLINOIS

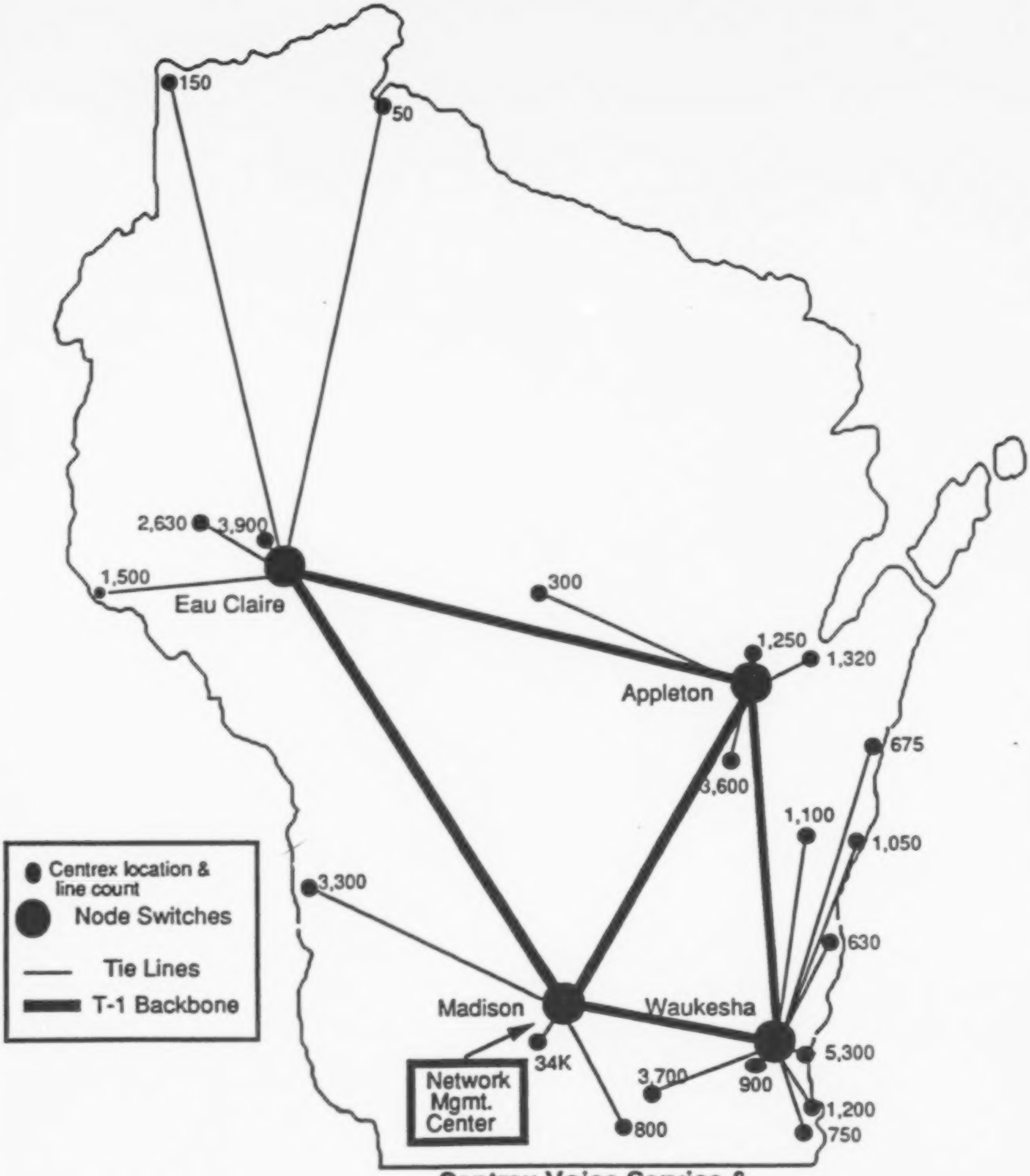
MCI NETWORK - WISCONSIN


SUPERIOR
IRON MOUNTAIN
MINNEAPOLIS
EAU CLAIRE
WAUSAU
RIVER FALLS
STEVENS POINT
GREEN BAY
APPLETON
LA CROSSE
SHEBOYGAN
BROOKFIELD
MADISON
MILWAUKEE
RACINE
JANESVILLE
N

SCALE: 1 in=42 mi

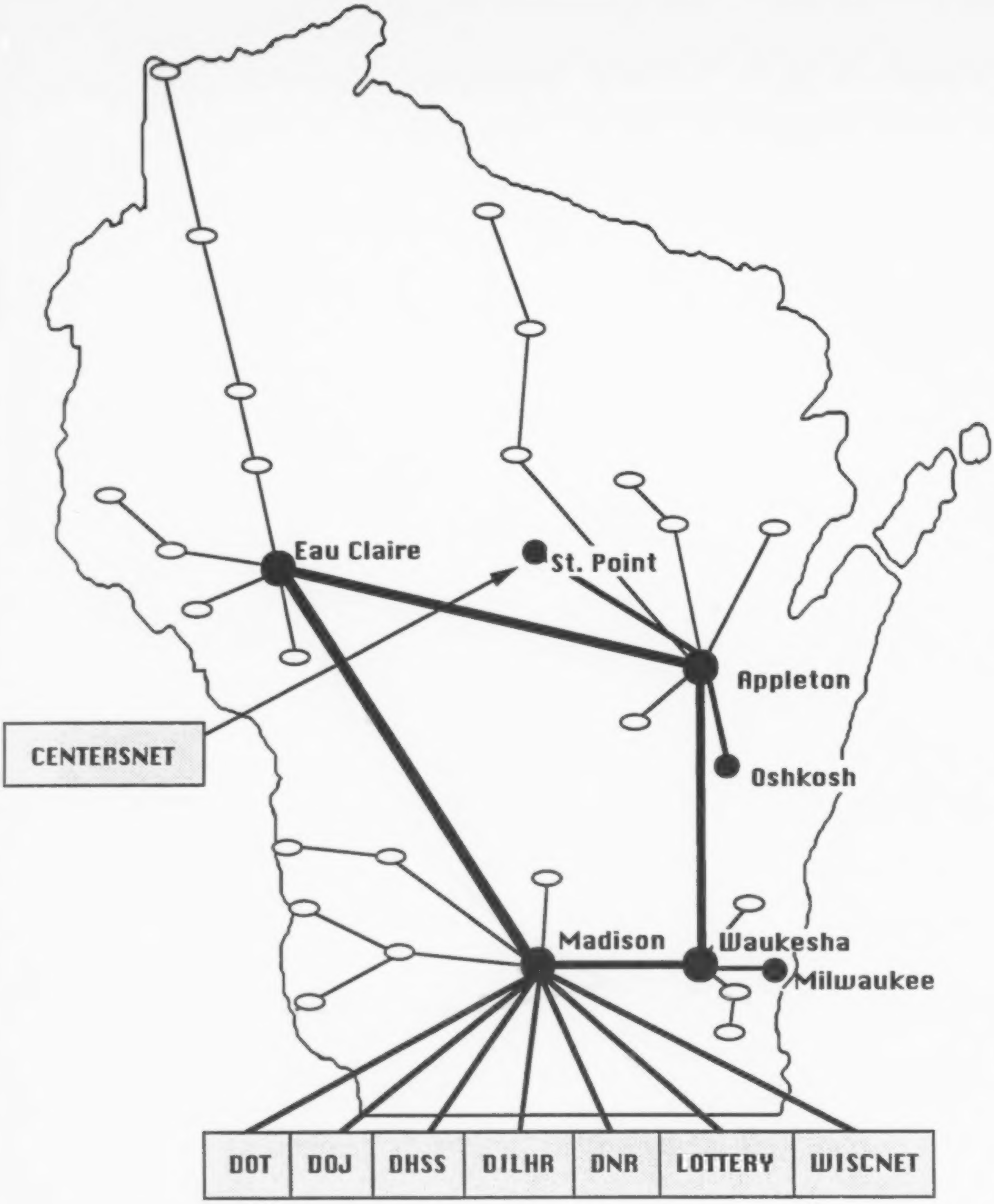
mci_net.wor John Dryer 8/92

WISCONSIN VOICE NETWORK


150
50
2,630
3,900
1,500
Eau Claire
300
1,250
1,320
Appleton
675
3,600
1,100
1,050
3,300
630
Madison
Waukesha
5,300
34K
3,700
900
Network Mgmt. Center
1,200
800
750
Centrex location & line count
Node Switches
Tie Lines
T-1 Backbone

Centrex Voice Service & State Telephone System

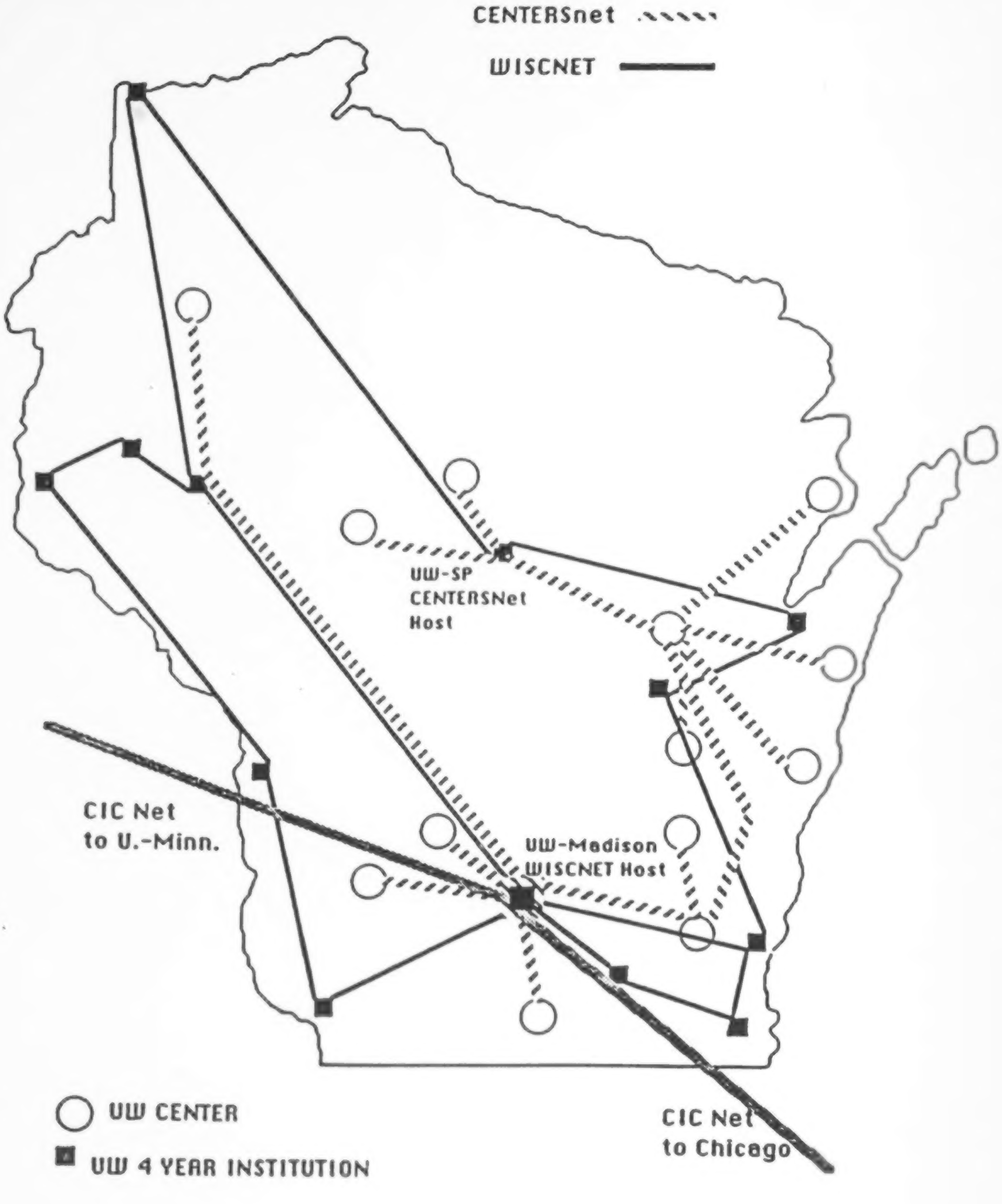
Wisconsin Consolidated Data Network


Eau Claire
St. Point
Appleton
CENTERSNET
Oshkosh
Madison
Waukesha
Milwaukee
DOT
DOJ
DHSS
DILHR
DNR
LOTTERY
WISCNET

APPENDIX D-10

UNIVERSITY OF WISCONSIN SYSTEM

PROPOSED INTER-CAMPUS NETWORKS


CENTERSnet
WISCNET
UW-SP
CENTERSNet
Host
CIC Net
to U.-Minn.
UW-Madison
WISCNET Host
CIC Net
to Chicago
○ UW CENTER
■ UW 4 YEAR INSTITUTION

ATTACHMENT D18

APPENDIX D-11

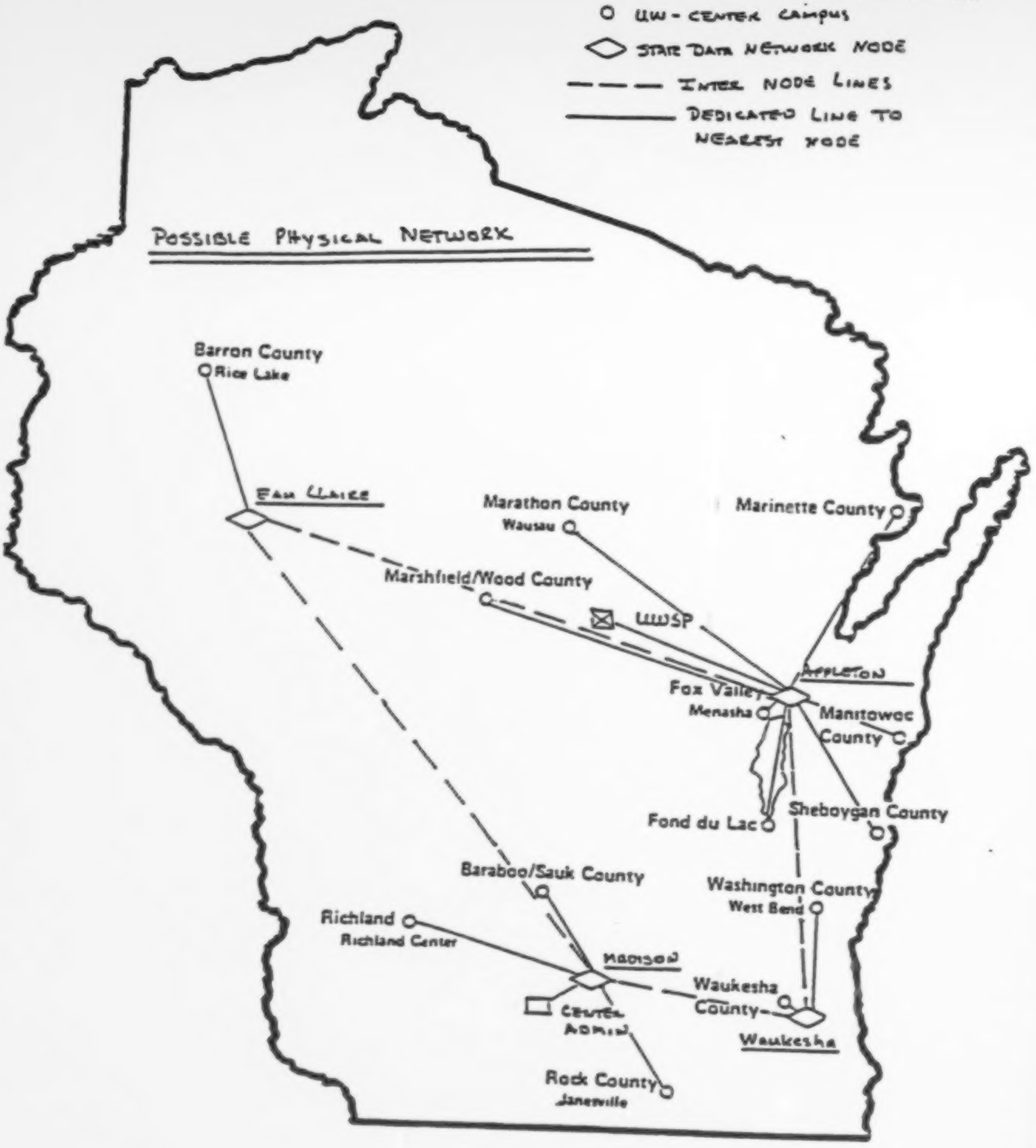

O UW-CENTER CAMPUS
◇ STATE DATA NETWORK NODE
— — — INTER NODE LINES
——— DEDICATED LINE TO NEAREST NODE
POSSIBLE PHYSICAL NETWORK
Barron County
Rice Lake
EAU CLAIRE
Marathon County
Wausau
Marinette County
Marshfield/Wood County
UWSP
APPLETON
Fox Valley
Menasha
Manitowoc County
Fond du Lac
Sheboygan County
Baraboo/Sauk County
Washington County
West Bend
Richland
Richland Center
MADISON
Waukesha County
CENTER ADMIN
Waukesha
Rock County
Janesville

Diagram of CENTERSnet

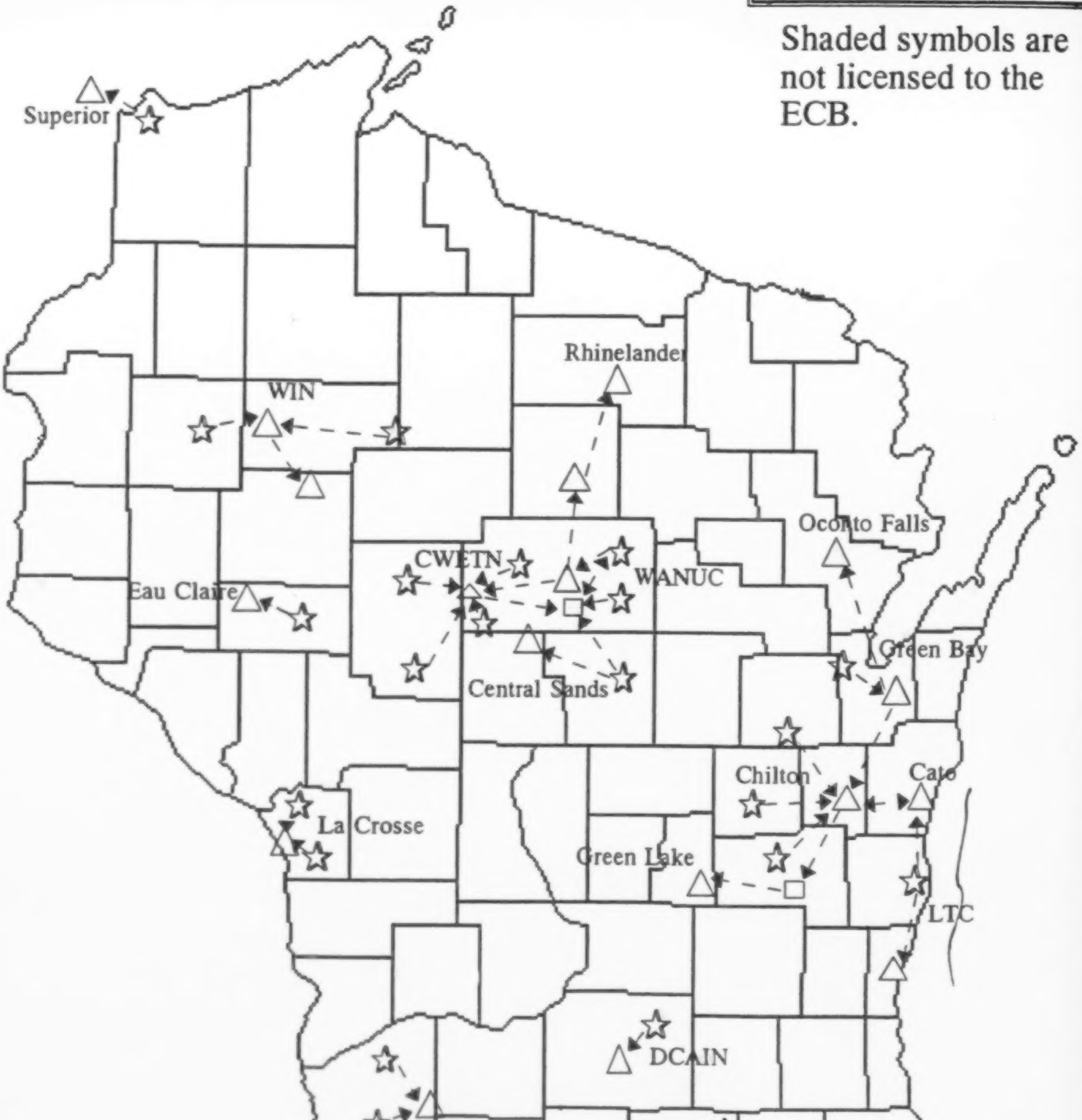
APPENDIX D-12

ECB sponsored Microwave Distance Learning Systems

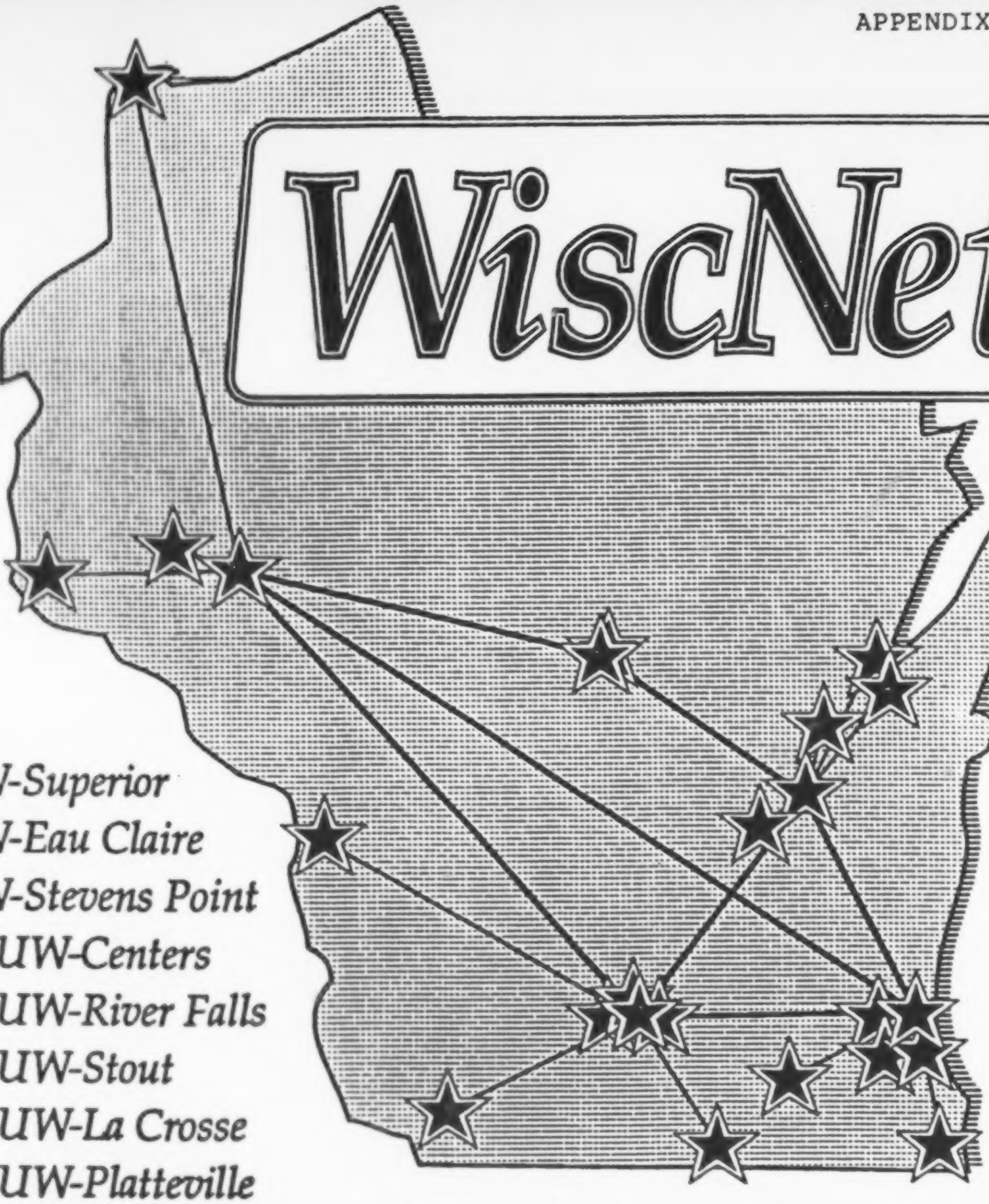
MAP KEY

△ ITFS Transmitter Site
◇ City (W/Number of receive sites)
☆ Studio Site
□ Point to Point Microwave
○ SERC Satellite Dish
← - → Direction of Signal

Shaded symbols are not licensed to the ECB.


Superior
WIN
Rhinelander
Oconto Falls
CWETN
WANUC
Eau Claire
Central Sands
Green Bay
Chilton
Cato
La Crosse
Green Lake
LTC
DCAIN
Platteville
GRADES

WiscNet

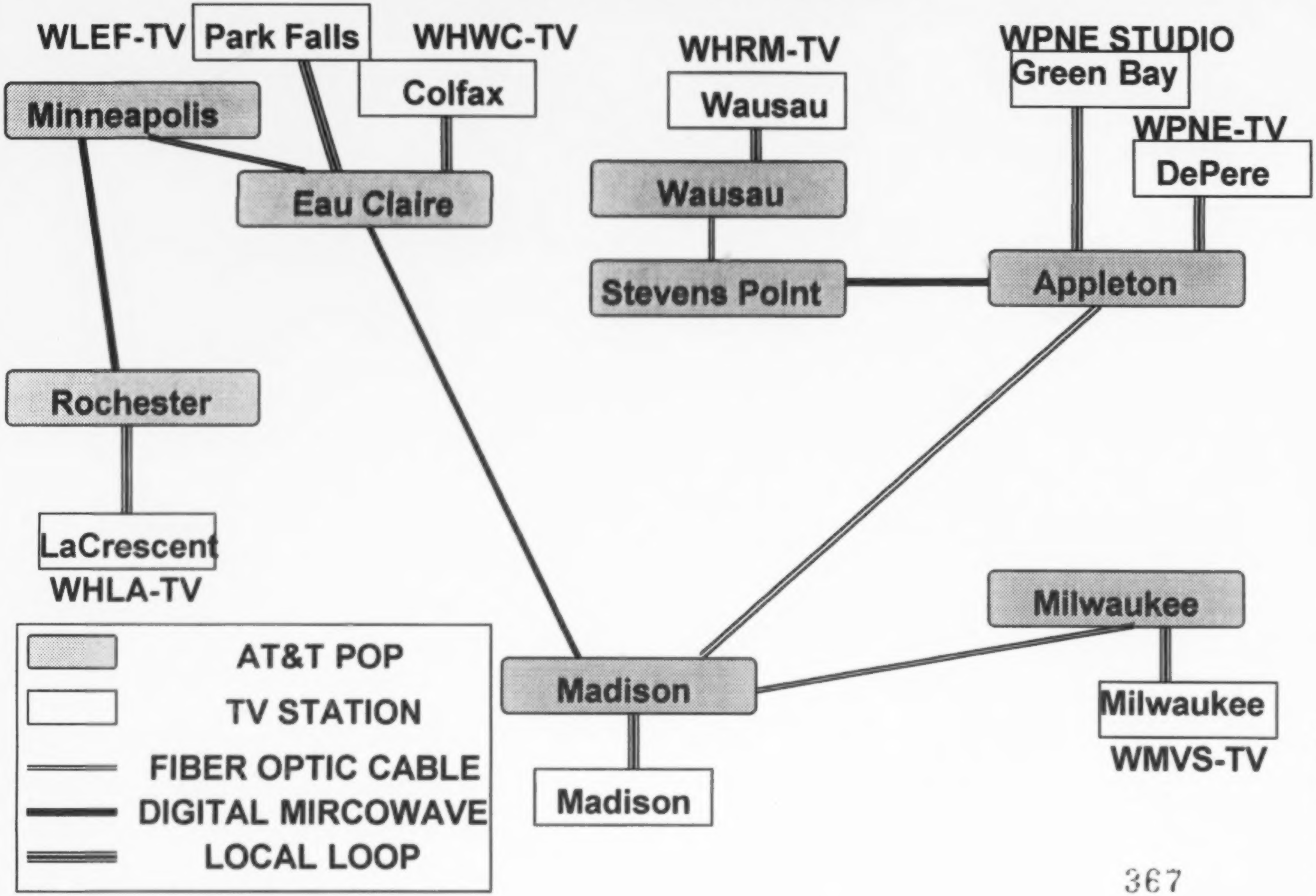


UW-Superior
UW-Eau Claire
UW-Stevens Point
UW-Centers
UW-River Falls
UW-Stout
UW-La Crosse
UW-Platteville
Edgewood College
UW-Extension
UW-Madison
UW System
Beloit College
UW-Whitewater

UW-Oshkosh
Ripon College
UW-Green Bay
St. Norbert College
Lawrence University
Medical College of Wisconsin

Marquette University
UW-Milwaukee
Carroll College
UW-Parkside

AT&T NETWORK



WLEF-TV Park Falls

WHWC-TV Colfax

Minneapolis

Eau Claire

WHRM-TV Wausau

Wausau

Stevens Point

WPNE STUDIO Green Bay

WPNE-TV DePere

Appleton

Rochester

LaCrescent WHLA-TV

Madison

Madison

Milwaukee

Milwaukee WMVS-TV

▨ AT&T POP

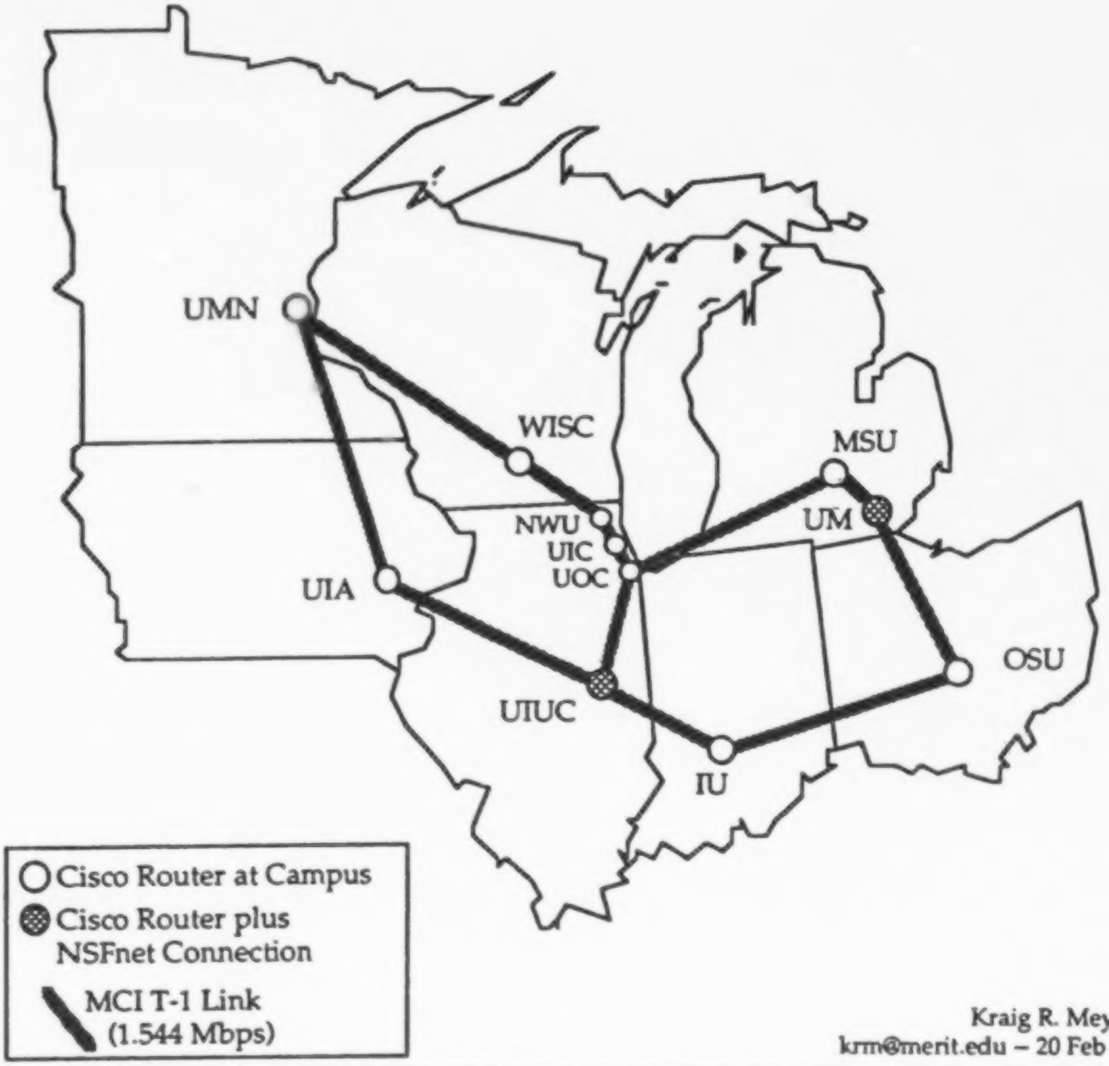
☐ TV STATION

═ FIBER OPTIC CABLE

━ DIGITAL MIRCOWAVE

≡ LOCAL LOOP

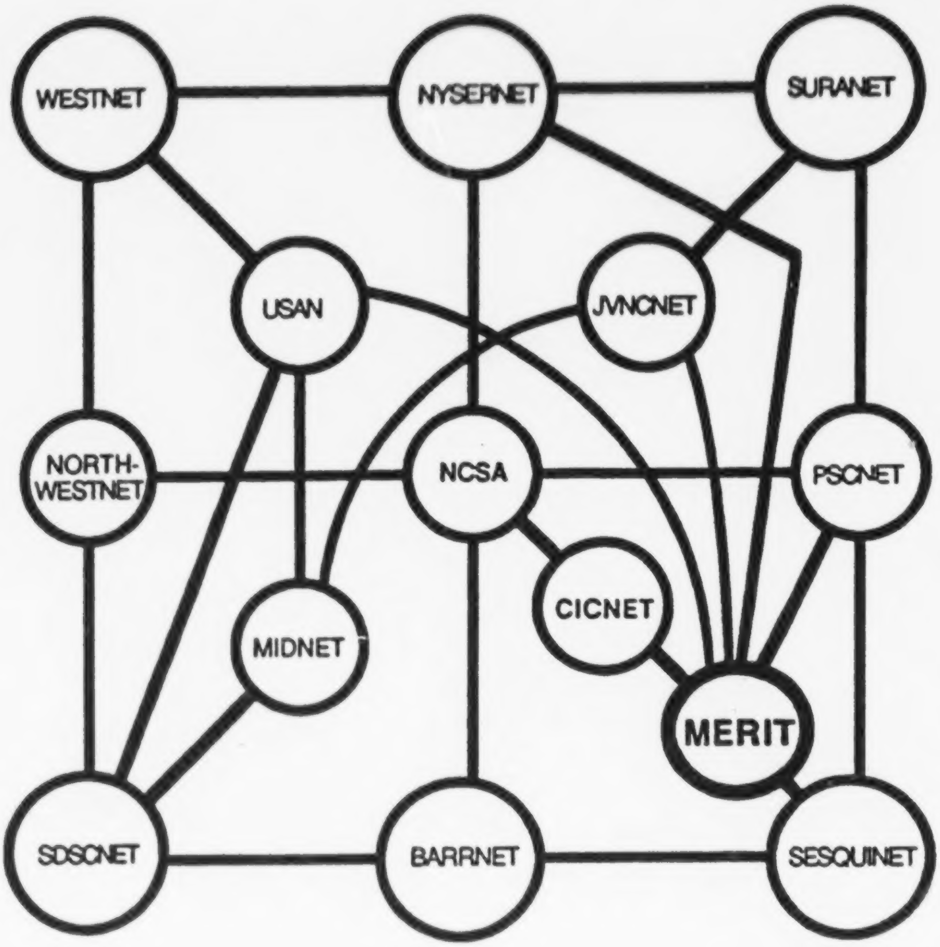
CICNET Backbone Network


UMN
WISC
MSU
NWU
UIC
UOC
UM
UIA
OSU
UIUC
IU
○ Cisco Router at Campus
● Cisco Router plus NSFnet Connection
MCI T-1 Link (1.544 Mbps)

Kraig R. Meyer
krm@merit.edu – 20 Feb 89

Abbreviation	Institution	Location
UIA	University of Iowa	Iowa City, Iowa
IU	Indiana University	Bloomington, Indiana
UMN	University of Minnesota	Minneapolis-St. Paul, Minnesota
MSU	Michigan State University	East Lansing, MI
NWU	Northwestern University	Evanston, IL
OSU	Ohio State University	Columbus, OH
UIC	Univ. of Illinois at Chicago	Chicago, IL
UIUC	Univ. of Illinois at Urbana-Champaign	Urbana-Champaign, IL
UM	University of Michigan	Ann Arbor, MI
UOC	University of Chicago	Chicago, IL
WISC	University of Wisconsin	Madison, WI

(Chicago area distorted to aid in the illustration of network topology)

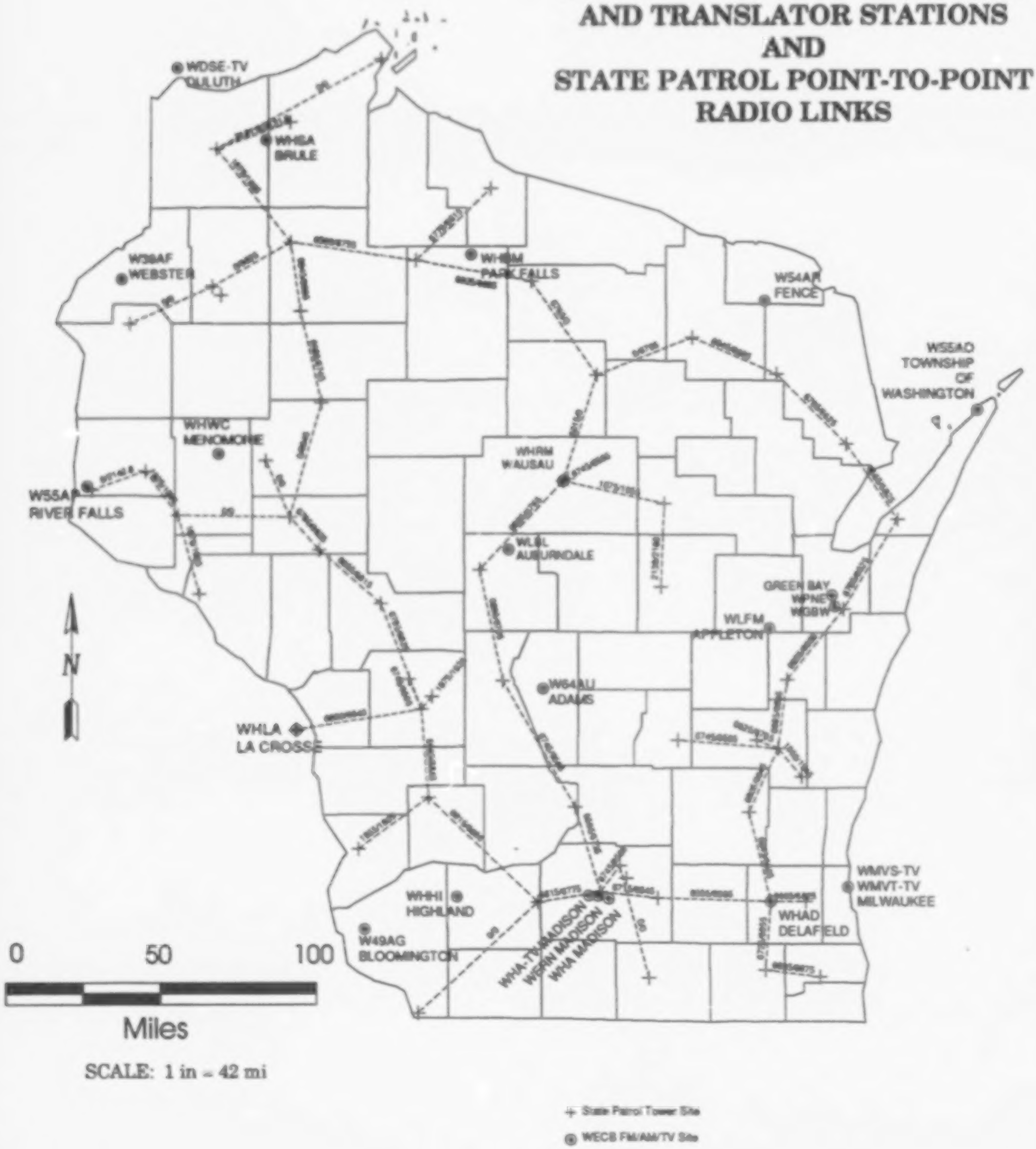

WESTNET
NYSERNET
SURANET
USAN
JVNCNET
NORTH-WESTNET
NCSA
PSCNET
CICNET
MIDNET
MERIT
SDSCNET
BARRNET
SESQUINET

NSFNET LOGICAL TOPOLOGY

(All Circuits are 1.5 Mbps)

MJE 4/20/89

STATE EDUCATIONAL AM/FM/TV AND TRANSLATOR STATIONS AND STATE PATROL POINT-TO-POINT RADIO LINKS


WDSE-TV
DULUTH
WHSA
BRULE
W38AF
WEBSTER
WHBM
PARK FALLS
W54AR
FENCE
W55AD
TOWNSHIP
OF
WASHINGTON
WHWC
MENOMONIE
WHRM
WAUSAU
W55AR
RIVER FALLS
WLBL
AUBURNDALE
GREEN BAY
WPNE
WGBW
WLFM
APPLETON
W64AU
ADAMS
WHLA
LA CROSSE
WMVS-TV
WMVT-TV
MILWAUKEE
WHHI
HIGHLAND
WHA-TV MADISON
WERN MADISON
WHA MADISON
WHAD
DELAFIELD
W49AG
BLOOMINGTON
N
0
50
100
Miles
SCALE: 1 in = 42 mi
+ State Patrol Tower Site
◉ WECB FM/AM/TV Site

fmtv_sp John Dyer 8/92

LOCATIONS OF WECB FM & TV FACILITIES

Call Ltrs	Ch	City	ERP	ANT(m)	Coordinates
WMVS-TV	10	Milwaukee	309	517	43-05-48; 87-54-19
WPNE-TV	38	Green Bay	1070	585	44-24-35; 88-00-05
WHRM-TV	20	Wausau	1450	690	44-55-14; 89-41-31
WHWC-TV	28	Colfax	1100	655	45-02-47; 91-51-42
WHLA-TV	31	La Crosse	1200	614	43-48-17; 91-22-06
WLEF-TV	36	Park Falls	741	920	45-56-43; 90-16-28
WPNE-FM	207	Green Bay	100	513	44-24-35; 88-00-05
WHAD-FM	214	Delafield	79	491	43-01-56; 88-23-31
KUWS-FM	217	Superior	83	501	46-47-21; 92-06-51
WHRM-FM	215	Wausau	77	728	44-55-14; 89-41-31
WHWC-FM	202	Menomonie	20	625	45-02-47; 91-51-42
WHLA-FM	212	La Crosse	100	574	43-48-17; 91-22-06
WLEF-FM	212	Park Falls	17.7	694	45-56-43; 90-16-28
WLFM-FM	216	Appleton	10.5	268	44-15-42; 88-23-47
WYDR-FM	217	Eau Claire	.55	344	44-47-38; 91-31-22
WHSA-FM	210	Brule	38	168	46-27-59; 91-33-56
WHHI-FM	217	Highland	100	484	43-02-58; 90-22-00
WERN-FM	204	Madison	25	694	43-03-20; 89-32-07

EVANS ASSOCIATES
Consulting Engineers

LINKING WECB EDUCATIONAL BROADCAST NETWORK WITH STATE PATROL MICROWAVE BACKBONE

TABULATION OF REQUIRED ANTENNA HEIGHTS

NAME OF SITE	SITE COORDINATES		SITE TOWER HT. (feet)	LINKED WITH SITE	LINKED SITE COORDS.		LINKED SITE TOWER HT. (feet)	LINK DISTANCE (miles)	ANTENNA AZIMUTH (° True)	REQD. ANT. HEIGHT AGL (feet)
	LATITUDE	LONGITUDE			LATITUDE	LONGITUDE				
WHSA BRULE	46.466389	91.565556	400	IRON RIVER	46.546944	91.413889	380	9.1	52.4	205
WHBM PARK FALLS	45.945278	90.274444	1499	PARK FALLS	45.918611	90.620000	260	16.8	263.8	110
WHRM WAUSAU	44.920556	89.691944	647	RIB MOUNTAIN	44.920556	89.691944	647	0.0	0.0	75
WHWC MENOMONIE	45.046389	91.861667	1200	CHIPPEWA FALLS	45.016667	91.562778	320	14.8	97.9	275
WLBL AUBURNDALE	44.614444	90.035556	455	CARY MOUND	44.525278	90.216389	300	10.8	235.4	100
WGBW GREEN BAY	44.358889	87.985278	1025	DE PERE	44.346389	87.929444	260	2.9	107.3	90
WPNE GREEN BAY	44.409722	88.001389	1149	DE PERE	44.346389	87.929444	260	5.6	140.8	80
WHLA LA CROSSE	43.804722	91.368333	176	La Crescent, MN 2	43.804444	91.371667	677	0.2	263.4	50
WLFM APPLETON	44.261667	88.396389	199	CHILTON 1	44.028333	88.285556	400	17.0	161.1	105
WHA MADISON	43.041667	89.408611	258	HILL FARMS	43.073611	89.460000	138	3.4	310.3	245
WHHI HIGHLAND	43.049444	90.366667	417	BLUE MOUNDS	43.026389	89.853889	345	26.0	93.3	80
WHAD DELAFIELD	43.032222	88.391944	410	DELAFIELD	43.032222	88.391944	410	0.0	0.0	100
WERN MADISON	43.055000	89.478333	1200	HILL FARMS	43.073611	89.460000	138	1.6	35.8	75
WDSE-TV DULUTH	46.791944	92.122500	788	BENNETT	46.423889	91.878333	320	28.0	155.4	75
W39AF WEBSTER	45.840000	92.472778	425	FREDERIC	45.637778	92.421667	222	14.2	170.0	75
WLEF-TV PARK FALLS	45.945278	90.274444	1499	PARK FALLS	45.918611	90.620000	260	16.8	263.8	110
W54AR FENCE	45.736944	88.428611	499	LAKEWOOD	45.404444	88.353056	190	23.3	170.9	275
W55AO TOWNSHIP OF WASHINGTON	45.241667	87.091667	499	MARINETTE	45.086944	87.912500	245	41.5	255.3	195
WPNE-TV GREEN BAY	44.409722	88.001389	1149	DE PERE	44.346389	87.929444	260	5.6	140.8	80
WHWC-TV MENOMONIE	45.046389	91.861667	1200	CHIPPEWA FALLS	45.016667	91.562778	320	14.8	97.9	275
W55AP RIVER FALLS	44.902778	92.690833	368	ST CROIX	44.886111	92.657778	100	2.0	125.3	75
WHRM-TV WAUSAU	44.920556	89.691944	647	RIB MOUNTAIN	44.920556	89.691944	647	0.0	0.0	75
W64AU ADAMS	43.987778	89.818056	250	NECEDAH	44.022778	90.072222	85	12.9	280.9	100
WHLA-TV LA CROSSE	43.804722	91.368333	176	La Crescent, MN 2	43.804444	91.371667	677	0.2	263.4	65
W49AG BLOOMINGTON	42.903333	90.950278	500	SENECA	43.268611	90.983611	260	25.3	356.2	300
WHA-TV MADISON	43.055556	89.535278	1048	HILL FARMS	43.073611	89.460000	138	4.0	71.9	120
WMVS/WMVT-TV MILWAUKEE	43.096667	87.905278	1101	WAUKESHA-D2	43.032778	88.172222	70	14.2	252.0	500
IRON RIVER (STPATROL)	46.546944	91.413889	380	WHSA BRULE	46.466389	91.565556	400	9.1	232.4	210
PARK FALLS (STPATROL)	45.918611	90.620000	260	WHBM PARK FALLS	45.945278	90.274444	1499	16.8	83.8	105
RIB MOUNTAIN (STPATROL)	44.920556	89.691944	647	WHRM WAUSAU	44.920556	89.691944	647	0.0	0.0	75
CHIPPEWA FALLS (STPATROL)	45.016667	91.562778	320	WHWC MENOMONIE	45.046389	91.861667	1200	14.8	277.9	275
CARY MOUND (STPATROL)	44.525278	90.216389	300	WLBL AUBURNDALE	44.614444	90.035556	455	10.8	55.4	100
DE PERE (STPATROL)	44.346389	87.929444	260	WGBW GREEN BAY	44.358889	87.985278	1025	2.9	287.3	75
DE PERE (STPATROL)	44.346389	87.929444	260	WPNE GREEN BAY	44.409722	88.001389	1149	5.6	320.8	100
La Crescent MN2 (STPATRL)	43.804444	91.371667	677	WHLA LA CROSSE	43.804722	91.368333	176	0.2	83.4	50
CHILTON 1 (STPATROL)	44.028333	88.285556	400	WLFM APPLETON	44.261667	88.396389	199	17.0	341.1	105
HILL FARMS (STPATROL)	43.073611	89.460000	138	WHA MADISON	43.041667	89.408611	258	3.4	130.3	130
BLUE MOUNDS (STPATROL)	43.026389	89.853889	345	WHHI HIGHLAND	43.049444	90.366667	417	26.0	273.3	70
DELAFIELD (STPATROL)	43.032222	88.391944	410	WHAD DELAFIELD	43.032222	88.391944	410	0.0	0.0	100
HILL FARMS (STPATROL)	43.073611	89.460000	138	WERN MADISON	43.055000	89.478333	1200	1.6	215.8	65
BENNETT (STPATROL)	46.423889	91.878333	320	WDSE-TV DULUTH	46.791944	92.122500	788	28.0	155.4	200
FREDERIC (STPATROL)	45.637778	92.421667	222	W39AF WEBSTER	45.840000	92.472778	425	14.2	350.0	120
PARK FALLS (STPATROL)	45.918611	90.620000	260	WLEF-TV PARK FALLS	45.945278	90.274444	1499	16.8	83.8	100
LAKEWOOD (STPATROL)	45.404444	88.353056	190	W54AR FENCE	45.736944	88.428611	499	23.3	350.9	100
MARINETTE (STPATROL)	45.086944	87.912500	245	W55AO TOWNSHIP OF WASHINGTON	45.241667	87.091667	499	41.5	75.3	200
DE PERE (STPATROL)	44.346389	87.929444	260	WPNE-TV GREEN BAY	44.409722	88.001389	1149	5.6	320.8	100
CHIPPEWA FALLS (STPATROL)	45.016667	91.562778	320	WHWC-TV MENOMONIE	45.046389	91.861667	1200	14.8	277.9	275
ST CROIX (STPATROL)	44.886111	92.657778	100	W55AP RIVER FALLS	44.902778	92.690833	368	2.0	305.3	70
RIB MOUNTAIN (STPATROL)	44.920556	89.691944	647	WHRM-TV WAUSAU	44.920556	89.691944	647	0.0	0.0	75
NECEDAH (STPATROL)	44.022778	90.072222	85	W64AU ADAMS	43.987778	89.818056	250	12.9	100.9	70
LA CRESCENT MN2 (STPATRL)	43.804444	91.371667	677	WHLA-TV LA CROSSE	43.804722	91.368333	176	0.2	83.4	65
SENECA (STPATROL)	43.268611	90.983611	260	W49AG BLOOMINGTON	42.903333	90.950278	500	25.3	176.2	105
HILL FARMS (STPATROL)	43.073611	89.460000	138	WHA-TV MADISON	43.055556	89.535278	1048	4.0	251.9	125
WAUKESHA-D2 (STPATROL)	43.032778	88.172222	70	WMVS/WMVT-TV MILWAUKEE	43.096667	87.905278	1101	14.2	72.0	70

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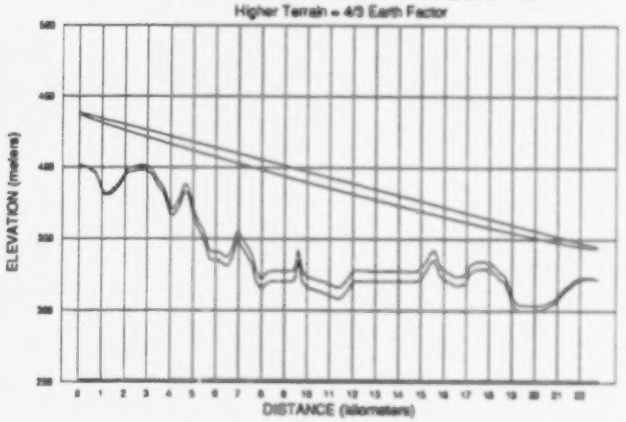
STATE OF WISCONSIN FEASIBILITY STUDY
MIRCOWAVE PATH PROFILES
FROM: STATE PATROL TOWER SITES TO: WECB EDUCATIONAL NETWORK SITES

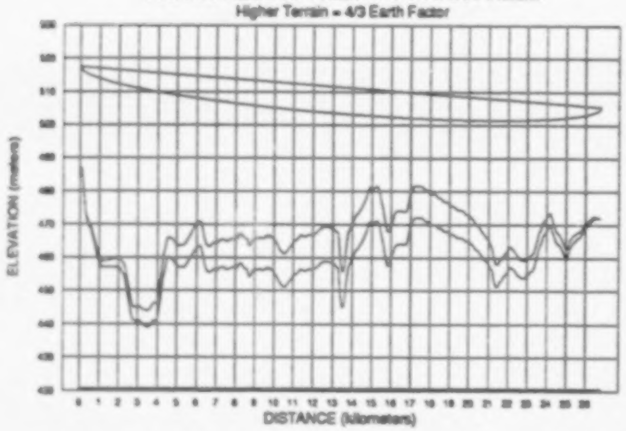
FREDERIC to W39AF WEBSTER

Higher Terrain = 4/3 Earth Factor



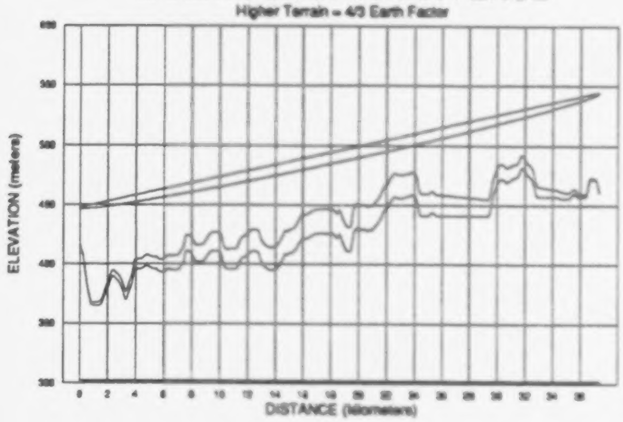
PARK FALLS to WLEF-TV PARK FALLS

Higher Terrain = 4/3 Earth Factor



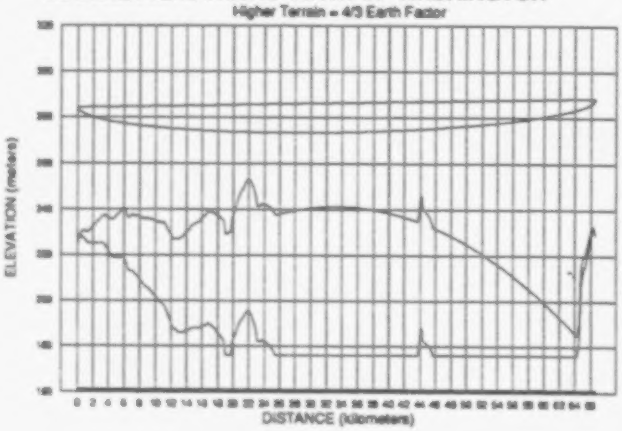
LAKEWOOD to W54AR FENCE

Higher Terrain = 4/3 Earth Factor



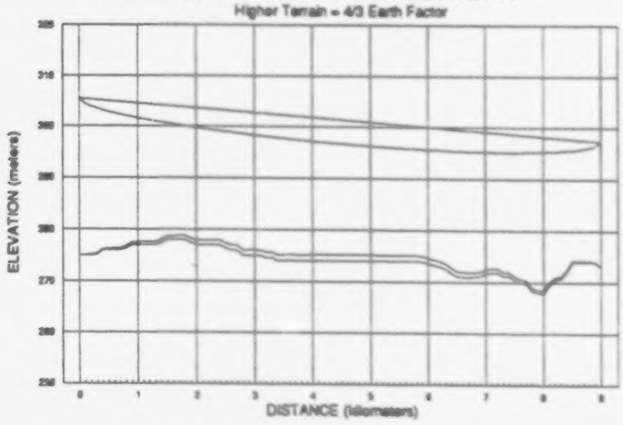
MARINETTE to W55AO TOWN OF WASHINGTON

Higher Terrain = 4/3 Earth Factor



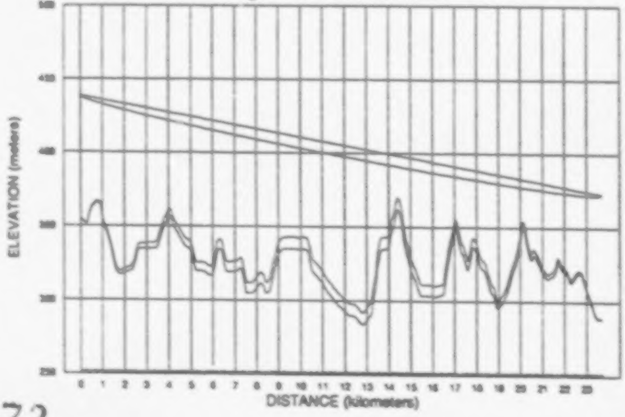
DE PERE to WPNE-TV GREEN BAY

Higher Terrain = 4/3 Earth Factor



CHIPPEWA FALLS to WHWC-TV MENOMONIE

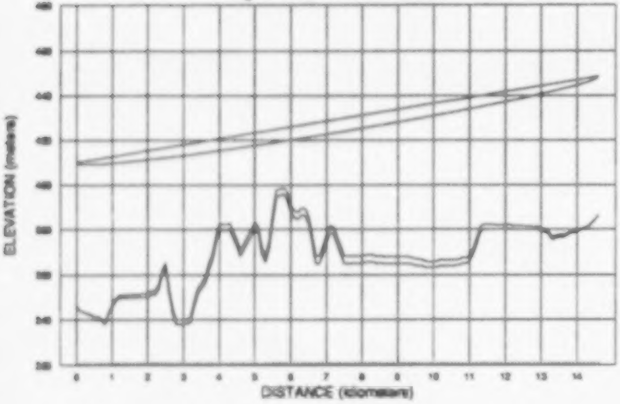
Higher Terrain = 4/3 Earth Factor



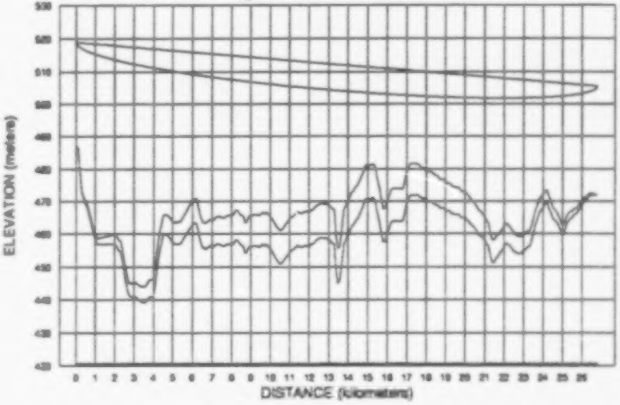
profiled by John Dyer 8/92

STATE OF WISCONSIN FEASIBILITY STUDY
MIRCOWAVE PATH PROFILES
FROM: STATE PATROL TOWER SITES TO: WECB EDUCATIONAL NETWORK SITES

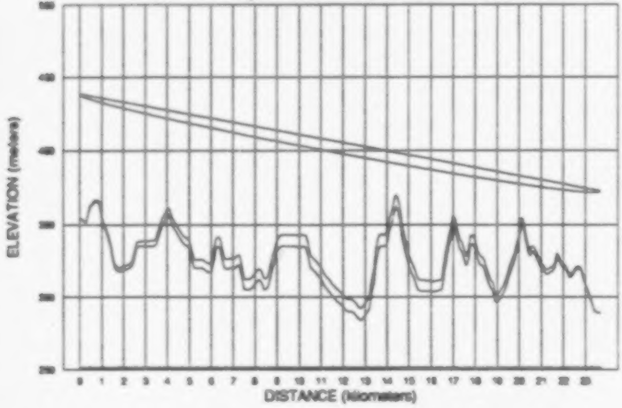
IRON RIVER to WHSA BRULE


Higher Terrain = 4/3 Earth Factor

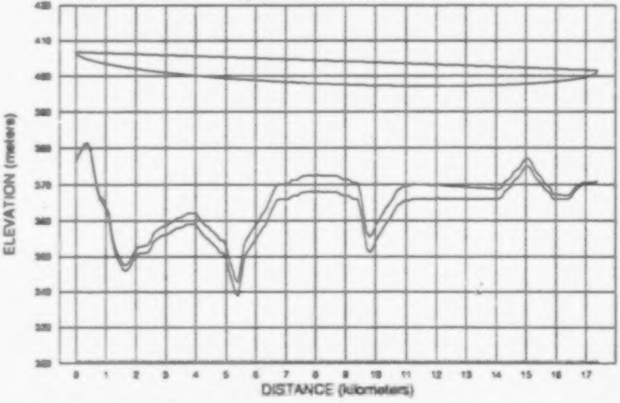
PARK FALLS to WHBM PARK FALLS


Higher Terrain = 4/3 Earth Factor

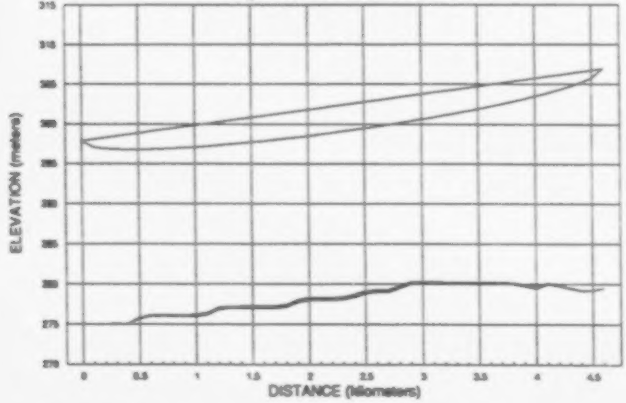
CHIPPEWA FALLS to WHWC MENOMONIE


Higher Terrain = 4/3 Earth Factor

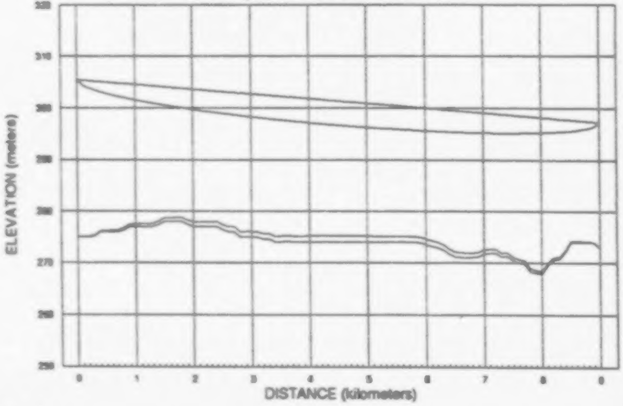
CARY MOUND to WLBL AUBURNDALE


Higher Terrain = 4/3 Earth Factor

DE PERE to WGBW GREEN BAY


Higher Terrain = 4/3 Earth Factor

DE PERE to WPNE GREEN BAY


Higher Terrain = 4/3 Earth Factor

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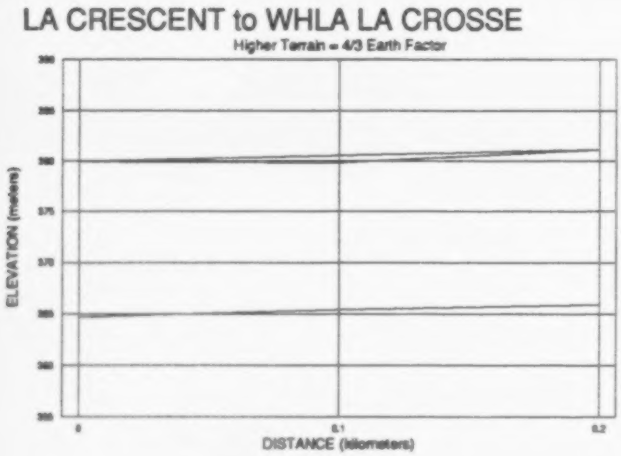
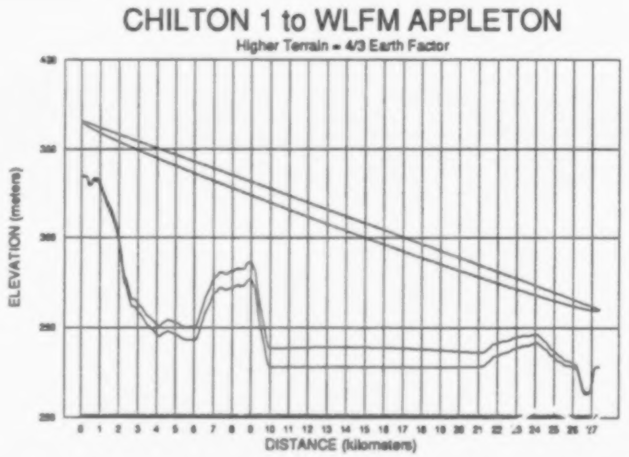
Consulting Engineers

STATE OF WISCONSIN FEASIBILITY STUDY
MIRCOWAVE PATH PROFILES
FROM: STATE PATROL TOWER SITES TO: WECB EDUCATIONAL NETWORK SITES



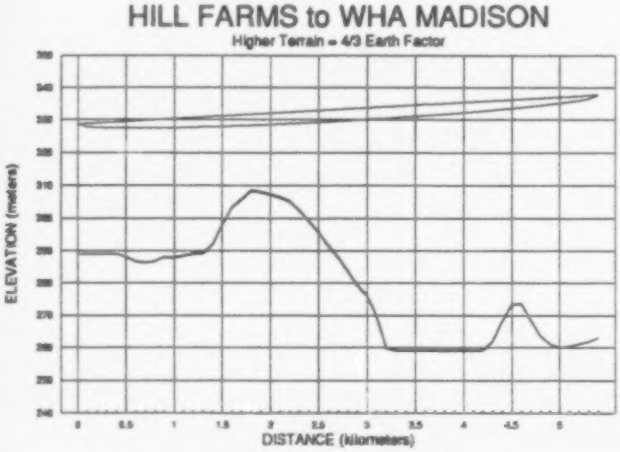
LA CRESCENT to WHLA LA CROSSE

Higher Terrain = 4/3 Earth Factor



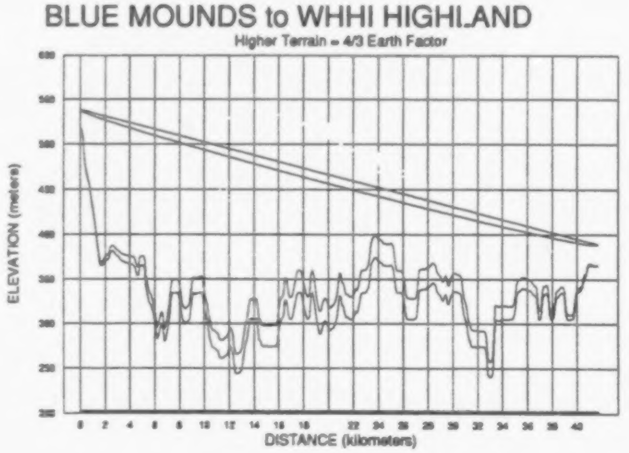
CHILTON 1 to WLFM APPLETON

Higher Terrain = 4/3 Earth Factor



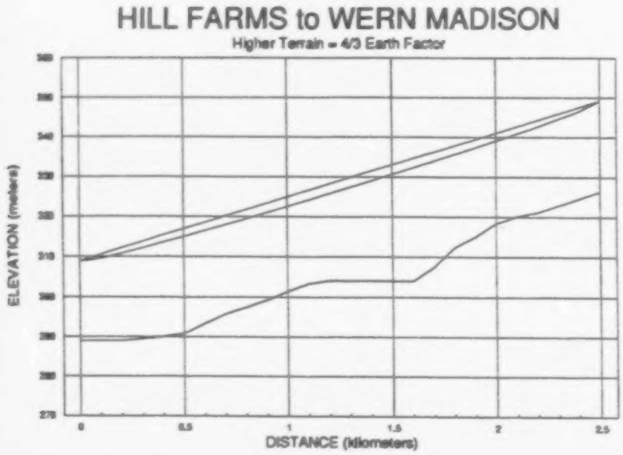
HILL FARMS to WHA MADISON

Higher Terrain = 4/3 Earth Factor



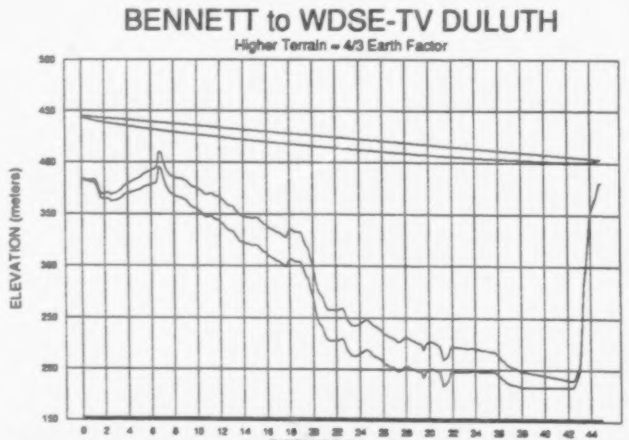
BLUE MOUNDS to WHHI HIGHLAND

Higher Terrain = 4/3 Earth Factor



HILL FARMS to WERN MADISON

Higher Terrain = 4/3 Earth Factor



BENNETT to WDSE-TV DULUTH

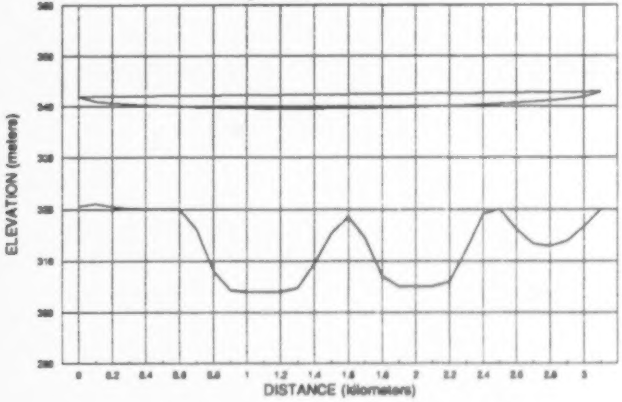
Higher Terrain = 4/3 Earth Factor

confidential John Dower 8/92

STATE OF WISCONSIN FEASIBILITY STUDY
MIRCOWAVE PATH PROFILES
FROM: STATE PATROL TOWER SITES TO: WECB EDUCATIONAL NETWORK SITES

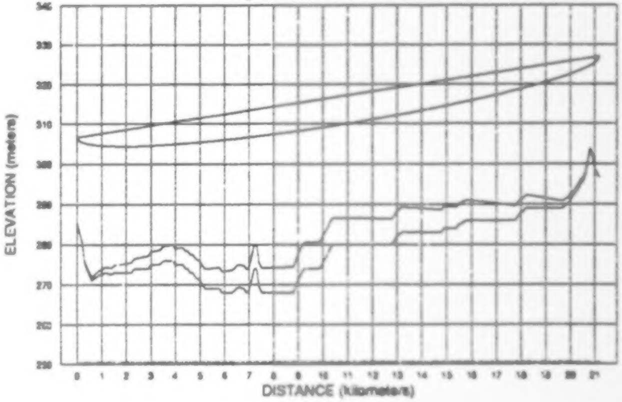
ST. CROIX to W55AP RIVER FALLS

Higher Terrain = 4/3 Earth Factor



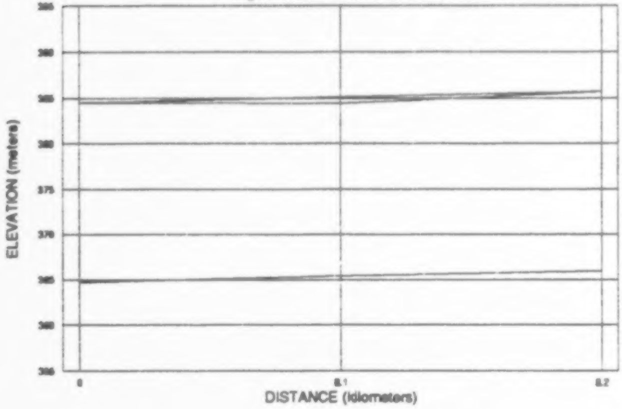
NECEDAH to W64AU ADAMS

Higher Terrain = 4/3 Earth Factor



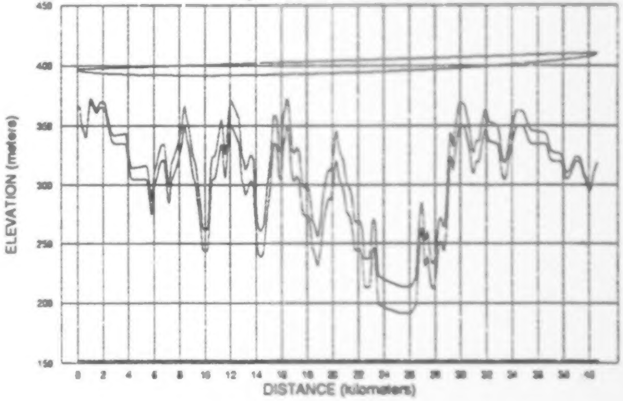
LA CRESCENT MN to WHLA-TV LA CROSSE

Higher Terrain = 4/3 Earth Factor



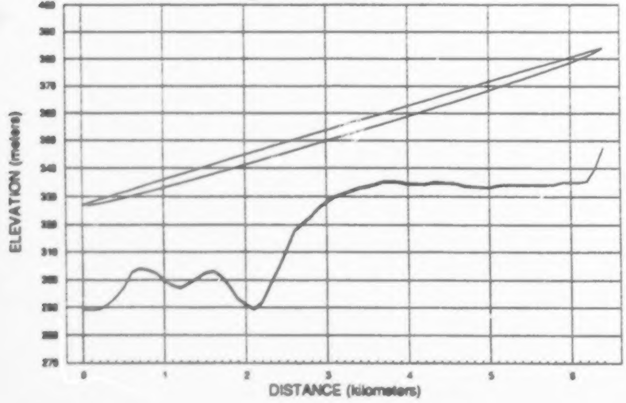
SENECA to W49AG BLOOMINGTON

Higher Terrain = 4/3 Earth Factor



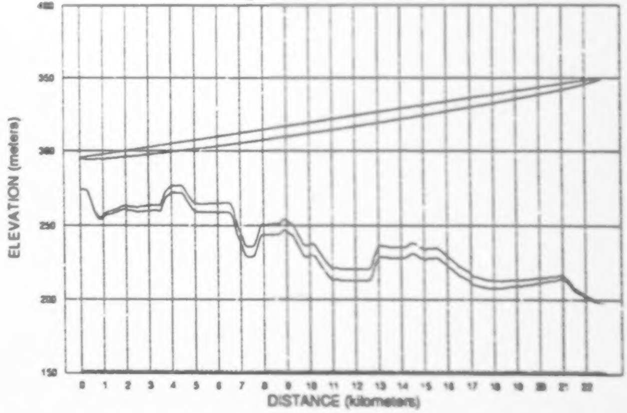
HILL FARMS to WHA-TV MADISON

Higher Terrain = 4/3 Earth Factor



WAUKESHA-D2 to WMVS/WMVT MILWAUKEE

Higher Terrain = 4/3 Earth Factor



[illegible] John Dover 8/92

INTERCONNECTION OF WECB AM/FM/TV VIA DOT MICROWAVE BACKBONE
PROJECTED COSTS

AT SITE	ROUTE	ITEM	COST
WECB BLDG MADISON	Links to Hill Farms, WHA-TV, WERN, WHA	These are existing links and require no new equipment. All Madison area AM/FM/TV stations in the WECB network are currently connected to the system.	$0.00
DOT HILL FARMS	Link to DOT Blue Mounds	ATI 6-DS3 Transceiver	$20,700
	Link to DOT Baraboo	ATI 6-DS3 Transceiver	20,700
	Link to DOT Deerfield	ATI 6-DS3 Transceiver	20,700
	to Blue Mounds/Baraboo/Deerfield	Codec and Multiplexing equipment	10,000
		Installation and testing	1,000
		Site Engineering	5,000
DOT BLUE MOUNDS	Link to ECB WHHI Highland	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		950 MHz Audio Transmitter	3,000
		70' 1/2" Coaxial Cable	250
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Strengthen Tower	10,000
	Link to DOT Ashridge	ATI 6-DS3 Transceiver	20,700
	Links to WHHI/Ashridge	Installation and testing	1,000
		Site Engineering	5,000
ECB WHHI HIGHLAND	Termination Point	950 MHz Audio Receiver	3,000
		80' 1/2" Coaxial Cable	280
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Installation and testing	1,000
DOT ASHRIDGE	Link from Blue Mounds	ATI 6-DS3 Transceiver	20,700
	Link to Seneca (2 GHz)	ATI 6-DS3 Transceiver	20,700
	Link to Ridgeville	ATI 6-DS3 Transceiver	20,700
	Links to Seneca/Ridgeville	Installation and testing	1,000
		Site Engineering	5,000
DOT SENECA	Link from DOT Ashridge	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
	Link to ECB W49AG Bloomington	6 GHz Transmitter	10,750
		105' EW64 Waveguide	1,610
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB W49AG BLOOMINGTON	Termination Point	6 GHz Receiver	10,550
		Parabolic Dish Antenna (6 GHz/6')	2,000
		300' EW64 Waveguide	4,600
		Installation and testing	1,000
DOT RIDGEVILLE	Link from DOT Ashridge	ATI 6-DS3 Transceiver	20,700
	Link to DOT La Crescent, MN	ATI 6-DS3 Transceiver	20,700
	Link to DOT Academy	ATI 6-DS3 Transceiver	20,700
	Links to La Crescent/Academy	Installation and testing	1,000
		Site Engineering	5,000
DOT LA CRESCENT, MN	Link to ECB WHLA/WHLA-TV	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		6 GHz Transmitter & Audio S.C.	11,900
		65' EW64 Waveguide	1,000
		Parabolic Dish Antenna (6 GHz/4')	1,700
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
WECB WHLA/WHLA-TV	Termination Point	6 GHz Receiver & Audio S.C.	11,700

INTERCONNECTION OF WECB AM/FM/TV VIA DOT MICROWAVE BACKBONE
PROJECTED COSTS

AT SITE	ROUTE	ITEM	COST
		65' EW64 Waveguide	1,000
		Parabolic Dish Antenna (6 GHz/4')	1,700
		Installation and testing	1,000
DOT ACADEMY	Link to DOT Black River Falls	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT BLACK RIVER FALLS	Link to DOT Osseo	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT OSSEO	Link to DOT Eau Claire	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT EAU CLAIRE	Link from DOT Osseo	ATI 6-DS3 Transceiver	20,700
	Link to DOT Elmwood	ATI 6-DS3 Transceiver	20,700
	Link to DOT Holcombe	ATI 6-DS3 Transceiver	20,700
	Link to DOT Chippewa Falls	ATI 6-DS3 Transceiver	20,700
	to Elmwood/Holcombe/Chippewa	Installation and testing	1,000
		Site Engineering	5,000
DOT ELMWOOD	Link to DOT Baldwin (2 GHz)	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT BALDWIN	Link to DOT St. Croix (2 GHz)	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT ST. CROIX	Link to ECB W55AP River Falls	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		Parabolic Dish Antenna (6 GHz/4')	1,700
		6 GHz Transmitter	10,750
		70' EW64 Waveguide	1,100
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB W55AP RIVER FALLS	Termination Point	6 GHz Receiver	10,550
		75' EW64 Waveguide	1,150
		Parabolic Dish Antenna (6 GHz/4')	1,700
		Installation and testing	1,000
DOT CHIPPEWA FALLS	Link to ECB WHWC Menomonie	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		6 GHz Transmitter	10,750
		275' EW64 Waveguide	4,200
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB WHWC MENOMONIE	Termination Point	6 GHz Receiver	10,550
		Parabolic Dish Antenna (6 GHz/6')	2,000
		275' EW64 Waveguide	4,200
		Installation and testing	1,000
DOT HOLCOMBE	Link to DOT Meteor	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT METEOR	Link to DOT Hayward	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT HAYWARD	Link from DOT Meteor	ATI 6-DS3 Transceiver	20,700

INTERCONNECTION OF WECB AM/FM/TV VIA DOT MICROWAVE BACKBONE
PROJECTED COSTS

AT SITE	ROUTE	ITEM	COST
	Link to DOT Spooner	ATI 6-DS3 Transceiver	20,700
	Link to DOT Bennett	ATI 6-DS3 Transceiver	20,700
	to Spooner/Bennett	Installation and testing	1,000
		Site Engineering	5,000
DOT SPOONER	Link to DOT Frederic	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT FREDERIC	Link from DOT Spooner	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
	Link to ECB W39AF Webster	6 GHz Transmitter	10,750
		120' EW64 Waveguide	1,850
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB W39AF WEBSTER	Termination Point	6 GHz Receiver	10,550
		Parabolic Dish Antenna (6 GHz/6')	2,000
		75' EW64 Waveguide	1,200
		Installation and testing	1,000
DOT BENNETT	Link to ECB WDSE-TV Duluth	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		6 GHz Transmitter	10,750
		200' EW64 Waveguide	3,000
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
	Link to DOT Iron River	ATI 6-DS1 Transceiver	13,000
	Links to WDSE-TV/Iron River	Installation and testing	1,000
		Site Engineering	5,000
ECB WDSE-TV DULUTH	Termination Point	6 GHz Receiver	10,550
		75' EW64 Waveguide	1,150
		Parabolic Dish Antenna (6 GHz/4')	1,700
		Installation and testing	1,000
DOT IRON RIVER	Link to ECB WHSA Brule	ATI 6-DS1 Transceiver	13,000
		Codec and Multiplexing equipment	10,000
		Parabolic Dish Antenna (950 MHz/6')	1,700
		210' Transmission Line	2,200
		950 MHz Audio Transmitter	3,000
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB WHSA BRULE	Termination Point	950 MHz Audio Receiver	3,000
		205' Transmission Line	2100
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Installation and testing	1,000
DOT BARABOO	Link to DOT Necedah	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT NECEDAH	Link to ECB W64AU Adams	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		6 GHz Transmitter	10,750
		70' EW64 Waveguide	1100
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
	Link to DOT Cary Mound	ATI 6-DS3 Transceiver	20,700
	Links to W64AU/Cary Mound	Installation and testing	1,000

INTERCONNECTION OF WECB AM/FM/TV VIA DOT MICROWAVE BACKBONE
PROJECTED COSTS

AT SITE	ROUTE	ITEM	COST
		Site Engineering	5,000
ECB W64AU ADAMS	Termination Point	6 GHz Receiver	10,550
		100' EW64 Waveguide	1,550
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Installation and testing	1,000
DOT CARY MOUND	Link to ECB WLBL Auburndale	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		950 MHz Audio Transmitter	3,000
		100' Transmission Line	1,000
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Strengthen Tower	10,000
	Link to DOT Rib Mountain	ATI 6-DS3 Transceiver	20,700
	Links to WLBL/Rib Mountain	Installation and testing	1,000
		Site Engineering	5,000
ECB WLBL AUBURNDALE	Termination Point	950 MHz Audio Receiver	3,000
		100' Transmission Line	1,000
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Installation and testing	1,000
DOT RIB MOUNTAIN	Link from DOT Cary Mound	ATI 6-DS3 Transceiver	20,700
	Link to WHRM/WHRM-TV	Codec and Multiplexing equipment	10,000
	Link to DOT Lookout	ATI 6-DS3 Transceiver	20,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT LOOKOUT	Link from DOT Rib Mountain	ATI 6-DS3 Transceiver	20,700
	Link to DOT Squirrel	ATI 6-DS3 Transceiver	20,700
	Link to DOT Crandon	ATI 6-DS3 Transceiver	20,700
	to Squirrel/Crandon	Installation and testing	1,000
		Site Engineering	5,000
DOT SQUIRREL	Link to DOT Park Falls	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT PARK FALLS	Link from DOT Squirrel	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
	Link to ECB WHBM/WLEF-TV	6 GHz Transmitter & Audio S.C.	11,900
		105' EW64 Waveguide	1,650
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB WHBM/WLEF-TV PARK FALLS	Termination Point	6 GHz Receiver & Audio S.C.	11,700
		Parabolic Dish Antenna (6 GHz/6')	2,000
		110' EW64 Waveguide	1,700
		Installation and testing	1,000
DOT CRANDON	Link to DOT Lakewood	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT LAKEWOOD	Link from DOT Crandon	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
	Link to ECB W54AR Fence	6 GHz Transmitter	10,750
		100' EW64 Waveguide	1,550
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB W54AR FENCE	Termination Point	6 GHz Receiver	10,550

INTERCONNECTION OF WECB AM/FM/TV VIA DOT MICROWAVE BACKBONE
PROJECTED COSTS

AT SITE	ROUTE	ITEM	COST
		Parabolic Dish Antenna (6 GHz/6')	2,000
		275' EW64 Waveguide	4,250
		Installation and testing	1,000
DOT DEERFIELD	Link to DOT Delafield	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT DELAFIELD	Link from DOT Deerfield	ATI 6-DS3 Transceiver	20,700
	Link to WHAD	Codec and Multiplexing equipment	10,000
	Link to DOT Waukesha	ATI 6-DS3 Transceiver	20,700
	Link to Neda	ATI 6-DS3 Transceiver	20,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT WAUKESHA	Link from DOT Delafield	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
	Link to ECB WMVS/WMVT Milw.	6 GHz Transmitter	10,750
		70' EW64 Waveguide	1,100
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB WMVS/WMVT MILW.	Termination Point	6 GHz Receiver	10,550
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Transmission Line	4,000
		Installation and testing	1,000
DOT NEDA	Link to DOT Eden	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT Eden	Link to DOT Chilton	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT CHILTON	Link to ECB WLFM Appleton	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		950 MHz Audio Transmitter	3,000
		105' Transmission Line	1000
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Strengthen Tower	10,000
	Link to DOT De Pere	ATI 6-DS3 Transceiver	20,700
	Links to WLFM/De Pere	Installation and testing	1,000
		Site Engineering	5,000
ECB WLFM APPLETON	Termination Point	950 MHz Audio Receiver	3,000
		105' Transmission Line	1000
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Installation and testing	1,000
DOT DE PERE	Link to ECB WPNE/WPNE-TV	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
		6 GHz Transmitter	10,750
		100' EW64 Waveguide	1,550
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Strengthen Tower	10,000
	Link to WGBW Green Bay	950 MHz Audio Transmitter	3,000
		75' Transmission Line	800
		Parabolic Dish Antenna (950 MHz/6')	1,700
	Link to DOT Brussels	ATI 6-DS3 Transceiver	20,700
		Installation and testing	1,000
		Site Engineering	5,000

APPENDIX E-13

EVANS ASSOCIATES
Consulting Engineers

INTERCONNECTION OF WECB AM/FM/TV VIA DOT MICROWAVE BACKBONE
PROJECTED COSTS

AT SITE	ROUTE	ITEM	COST
ECB WPNE/WPNE-TV	Termination Point	6 GHz Receiver	10,550
		80' EW64 Waveguide	1,500
		Parabolic Dish Antenna (6 GHz/6')	2,000
		Installation and testing	1,000
ECB WGBW GREEN BAY	Termination Point	950 MHz Audio Receiver	3,000
		90' Transmission Line	950
		Parabolic Dish Antenna (950 MHz/6')	1,700
		Installation and testing	1,000
DOT BRUSSELS	Link to DOT Marinette	ATI 6-DS3 Transceiver	23,700
		Installation and testing	1,000
		Site Engineering	5,000
DOT MARINETTE	Link from DOT Brussels	ATI 6-DS3 Transceiver	20,700
		Codec and Multiplexing equipment	10,000
	Link to ECB W55AO Town/Washington	6 GHz Transmitter	10,750
		200' EW64 Waveguide	3,100
		Parabolic Dish Antenna (6 GHz/8')	2,800
		Strengthen Tower	10,000
		Installation and testing	1,000
		Site Engineering	5,000
ECB W55AO TOWNSHIP OF WASHINGTON	Termination Point	6 GHz Receiver	10,550
		Parabolic Dish Antenna (6 GHz/8')	2,800
		195' EW64 Waveguide	3,000
		Installation and testing	1,000

TOTAL PROJECTED COST: $2,311,290

Projected Site Acquisition Cost: $810,100

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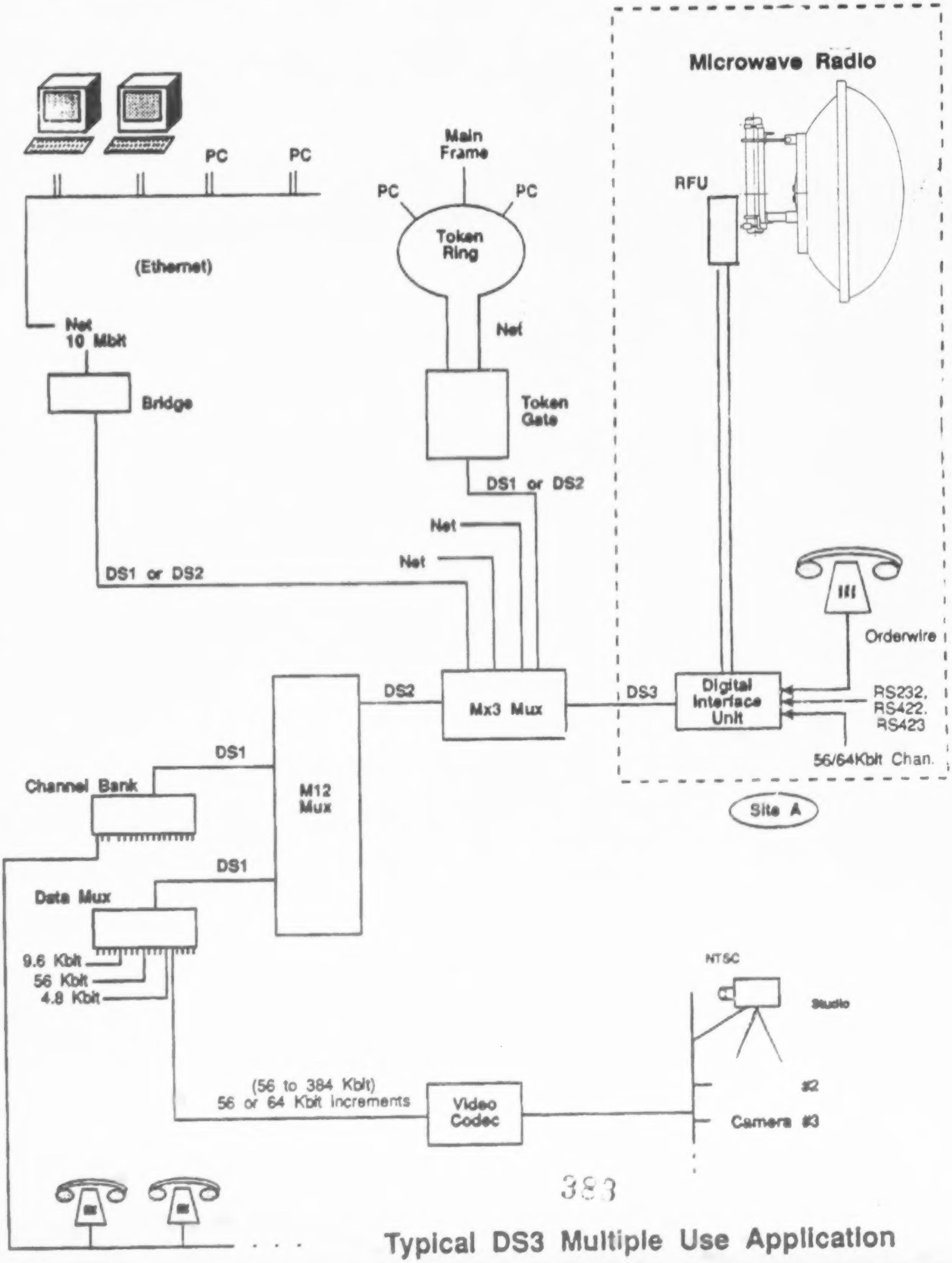

Microwave Radio
RFU
PC
PC
Main Frame
PC
PC
Token Ring
(Ethernet)
Net 10 Mbit
Net
Bridge
Token Gate
DS1 or DS2
Net
Net
DS1 or DS2
Orderwire
DS2
Mx3 Mux
DS3
Digital Interface Unit
RS232, RS422, RS423
56/64Kbit Chan.
Site A
DS1
Channel Bank
M12 Mux
DS1
Data Mux
9.6 Kbit
56 Kbit
4.8 Kbit
NTSC
Studio
(56 to 384 Kbit) 56 or 64 Kbit increments
Video Codec
#2
Camera #3
. . .

Typical DS3 Multiple Use Application

TOWER LOCATION LIST

Appendix F-1

Agency		Site	Latitude			Longitude		
ECB	1	BRULE	46	27	50	91	33	56
ECB	2	PARK FALLS	45	56	43	90	16	28
ECB	3	BURNETT	45	50	24	92	28	22
ECB	4	FLORENCE	45	44	13	88	25	43
ECB	5	SISTER BAY	45	14	30	87	5	30
ECB	6	CHILTON	44	1	46	88	17	10
ECB	7	COLFAX	45	2	49	91	51	46
ECB	8	LACRESCENT	43	48	17	91	22	6
ECB	9	ADAMS	43	59	16	89	49	5
ECB	10	BLOOMINGTON	42	54	12	90	57	1
ECB	11	DELAFIELD	43	1	56	88	23	31
ECB	12	SHEBOYGAN	43	42	12	87	45	9
ECB	13	CATO	44	6	55	87	51	27
ECB	14	LAKESHORE	43	55	30	87	45	6
ECB	15	ECB STL TO	44	47	38	91	31	22
ECB	16	ALBERTVILLE	44	53	4	91	35	5
ECB	17	WHA TOWER	43	3	18	89	28	42
ECB	18	WAUSAU	44	55	14	89	41	31
ECB	19	RHINELANDER	45	37	46	89	24	56
ECB	20	PLATTEVILLE	42	45	51	90	24	19
ECB	21	FENNIMORE	42	58	36	90	38	13
ECB	22	GREENBAY	44	24	32	88	0	12
ECB	23	GREENBAY	44	31	7	88	5	58
ECB	24	DULUTH	46	47	21	92	6	52
ECB	25	UNITY	44	49	35	90	14	28
ECB	26	GRANTON	44	35	36	90	27	45
ECB	27	WEYERHAUSER	45	25	16	91	25	10
DNR	4	MAUTHE	43	35	36	88	11	36
DNR	7	DEPERE	44	20	47	87	55	46
DNR	8	GREEN LAKE	43	45	28	88	58	15
DNR	17	LAKEWOOD	45	23	40	88	21	30
DNR	21	LOOKOUT	45	24	3	89	28	55
DNR	23	BENNETT	46	25	26	91	52	42
DNR	24	BAYFIELD	46	49	41	90	50	38
DNR	26	FREDERIC	45	38	16	92	25	18
DNR	27	HOLCOMBE	45	16	48	91	12	57
DNR	28	HAYWARD	46	0	10	91	24	32
DNR	29	METEOR	45	41	36	91	20	51
DNR	33	ELMWOOD	44	46	22	92	6	58
DNR	34	BLACK R.	44	22	30	90	50	30
DNR	35	OSSEO	44	36	51	91	13	48
DNR	37	RIDGEVILLE	43	53	44	90	35	0
DNR	39	LACRESCENT	43	48	16	91	22	18
DNR	44	BLUE	43	1	35	89	51	14
DNR	46	BARABOO	43	27	22	89	37	0
DNR	101	DANCY	44	43	10	89	49	10
DNR	102	GRESHAM	44	48	59	88	49	2
DNR	103	MERCER	46	14	23	90	9	4
DNR	104	BUTTERNUT	46	1	38	90	36	31
DNR	105	WAUTOMA	44	5	27	89	20	7
DNR	106	WAUSAUKEE	45	23	26	88	1	55
DNR	107	SOLDIERS	43	19	25	90	42	16
DNR	108	GOV. DODGE	43	1	22	90	8	21
DNR	109	LAMPSON	45	59	10	91	48	5

TOWER LOCATION LIST

Agency		Site	Latitude			Longitude		
DNR	110	EAGLE	42	52	35	88	31	28
DNR	111	SCANDINIVIA	44	28	5	89	10	27
DNR	113	DEVIL'S	43	25	49	89	44	5
DNR	114	WYALUSING	42	58	56	91	6	51
DNR	115	WAUSAUKEE	45	22	48	87	57	24
DNR	116	WAUTOMA	44	3	33	89	17	31
DNR	117	ASYLUM BAY	44	3	48	88	30	54
DNR	118	BRULE	46	32	0	91	35	35
DNR	119	PATTISON	46	32	17	92	7	5
DNR	120	KESHENA	44	53	23	88	39	56
DNR	121	CALUMET H.	43	54	55	88	19	38
DNR	122	PENISULA	45	7	51	87	13	52
DNR	123	POTAWATOMI	44	51	51	87	24	53
DNR	124	ANTIGO	45	9	17	89	8	49
DNR	125	FRIENDSHIP	43	57	59	89	48	59
DNR	126	SPOONER	45	49	17	91	53	56
DNR	127	BLACK R.	44	17	45	90	49	31
DNR	128	INTERSTATE	45	23	55	92	38	49
DNR	129	LAKE	44	58	40	91	18	45
DNR	130	WILLOW	45	0	43	92	41	2
DNR	131	HARTMAN	44	19	33	89	12	58
DNR	133	SISTER BAY	45	13	0	87	3	49
DNR	134	CLEAR LAKE	45	53	19	89	36	34
DNR	135	CRANDON	45	34	20	88	53	3
DNR	136	OCONTO	44	53	10	88	8	12
DNR	137	CUMBERLAND	45	32	10	92	2	20
DNR	138	JEFFERSON	42	59	38	88	53	49
DNR	139	MILWAUKEE	43	4	42	87	52	57
DNR	141	OGEMA	45	27	3	90	11	42
DNR	142	FLORENCE	45	53	49	88	14	42
DNR	143	FRIENDSHIP	43	59	12	89	49	8
DNR	144	PARK FALLS	45	55	46	90	26	30
DNR	145	WIS.	44	22	48	89	50	38
DNR	146	WHITING	44	29	12	89	33	11
DNR	147	MUSKY MTN.	45	59	28	89	35	57
DNR	148	WIS. DELLS	43	38	1	89	46	17
DNR	149	WAUSAU	44	54	33	89	39	7
DNR	150	FLAMBEAU	45	46	10	90	45	40
DNR	151	WASHBURN	46	40	20	90	54	1
DNR	152	GRANTSBURG	45	46	21	92	41	30
DNR	153	PERROT	44	1	28	91	28	52
DNR	154	LACROSSE	43	46	44	91	13	31
DNR	155	EAU CLAIRE	44	48	25	91	28	19
DNR	156	WILDCAT	43	42	7	90	34	17
DNR	158	BRUNET IS.	45	10	47	91	9	42
DNR	159	MARINETTE	45	2	22	87	38	44
DNR	160	GREEN BAY	44	32	40	88	3	4
DNR	161	OSHKOSH	44	0	39	88	31	35
DNR	162	HIGH CLIFF	44	9	55	88	17	15
DNR	163	POINT	44	12	43	87	30	33
DNR	164	BONG	42	38	1	88	7	38
DNR	165	BIG FOOT	42	34	9	88	25	5
DNR	167	KOHLER	43	39	17	87	43	34
DNR	169	BOSCOBEL	43	9	1	90	41	29

TOWER LOCATION LIST

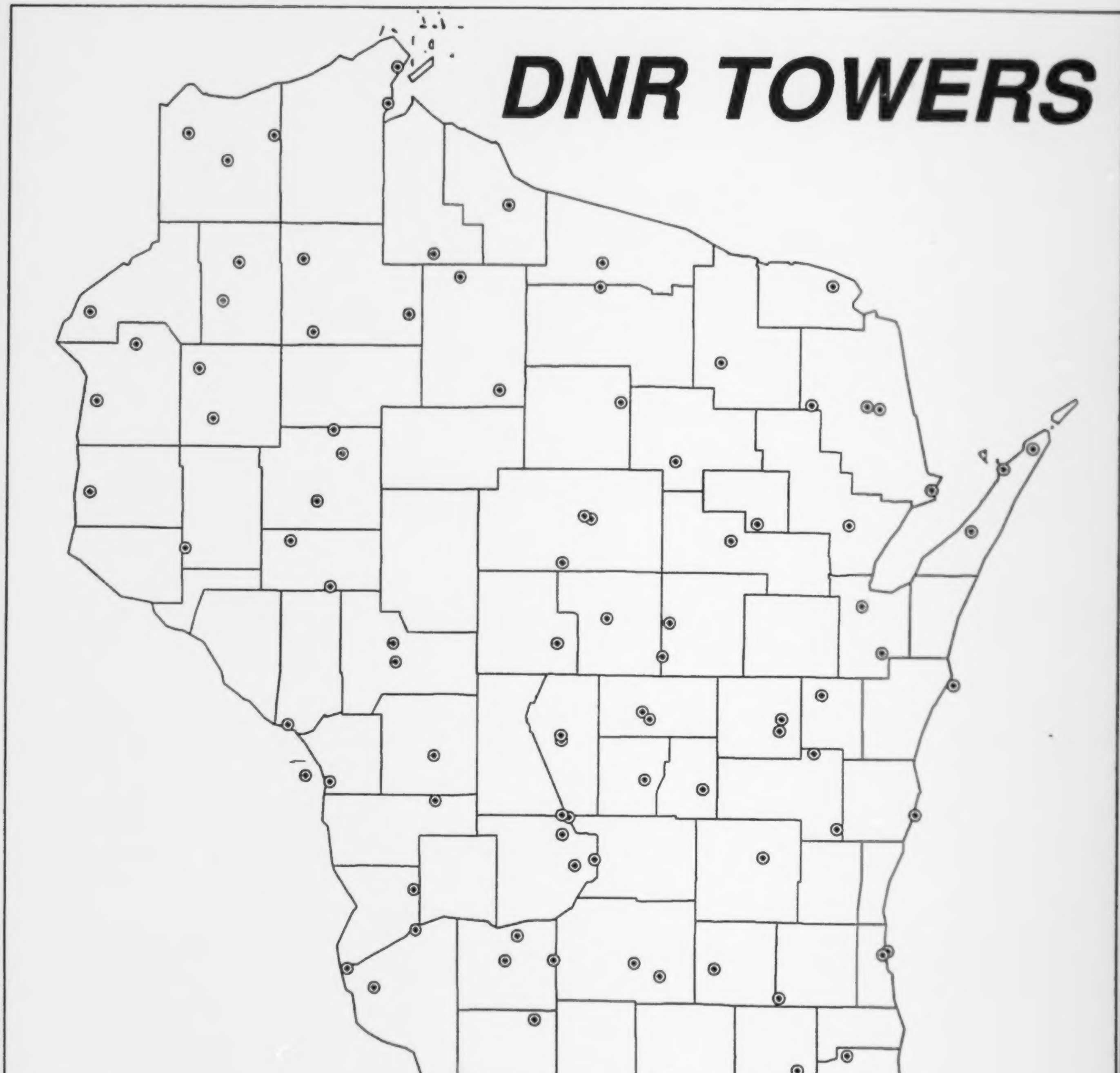
Appendix F-3

Agency		Site	Latitude			Longitude		
DNR	170	ROCKY	43	38	40	89	48	35
DNR	171	MIRROR	43	33	42	89	48	27
DNR	172	TOWER HILL	43	7	45	90	3	55
DNR	173	YELLOWSTONE	42	46	32	89	57	59
DNR	174	MADISON	43	1	1	89	22	41
DNR	175	HORICON	43	28	15	88	37	11
DNR	176	MONTELLO	43	47	50	89	19	7
DNR	177	EAGLE	42	52	35	88	31	28
DNR	178	LAKE	42	57	38	89	13	12
DNR	179	RIB MTN.	44	55	14	89	41	31
DNR	180	MILWAUKEE	43	3	40	87	54	46
DNR	200	HILLSDALE	45	19	38	91	57	7
DNR	201	BLOOMINGTON	42	54	12	90	57	1
DOT HWY	1	BLAIR	44	16	15	91	21	1
DOT HWY	2	STOUGHTON	42	57	13	89	8	14
DOT HWY	3	MUSKEGO	42	54	46	88	11	15
DOT HWY	4	WIS. RAPIDS	44	22	28	89	43	9
DOT HWY	6	WHEELER	45	2	47	91	51	42
DOT HWY	7	STARK	45	40	2	89	12	27
DOT HWY	8	HIGHLAND	46	27	59	91	33	56
DOT HWY	9	SPOONER	45	50	2	91	53	59
DOT HWY	10	DEPERE	44	24	35	88	0	5
DOT HWY	39	LACRESCENT	43	48	17	91	22	6
UW	1	WUEC, EAU	44	47	58	91	27	59
UW	2	WGBW	44	31	53	87	55	16
UW	3	WLSU, LA	43	48	42	91	11	15
UW	4	WHA,	43	2	30	89	24	31
UW	5	WHA-TV,	43	3	18	89	28	42
UW	6	WVSS,	44	52	17	91	55	34
UW	7	WUWM,	43	5	24	87	53	47
UW	8	WRST,	44	1	45	88	33	8
UW	9	WSUP,	42	43	57	90	29	9
UW	10	WRFW,	44	53	19	92	39	4
UW	11	WWSP,	44	32	17	89	35	43
UW	12	KUWS,	46	47	21	92	6	51
UW	13	WSUW,	42	50	10	88	44	36
UW	14	UW -	43	4	42	87	52	57
DOT SP	1	DELAFIELD	43	1	56	88	23	31
DOT SP	2	SPRING	42	43	34	88	25	42
DOT SP	2	SPRING	42	43	34	88	25	42
DOT SP	3	WAUKESHA-D	43	1	58	88	10	20
DOT SP	4	MAUTHE	43	35	36	88	11	36
DOT SP	5	FOND DU	43	45	30	88	28	35
DOT SP	6	CHILTON 1	44	1	42	88	17	8
DOT SP	6	CHILTON 2	44	1	42	88	17	8
DOT SP	7	DE PERE	44	20	47	87	55	46
DOT SP	8	GREENLAKE	43	45	28	88	58	15
DOT SP	9	BRUSSELS	44	44	58	87	35	28
DOT SP	10	MARINETTE	45	5	13	87	54	45
DOT SP	11	EDEN	43	43	18	88	20	30
DOT SP	12	WAUSAU-D4	44	55	52	89	39	50
DOT SP	13	RIB	44	55	14	89	41	31
DOT SP	14	WITTENBERG	44	49	14	89	3	28
DOT SP	15	CRANDON	45	34	20	88	53	2

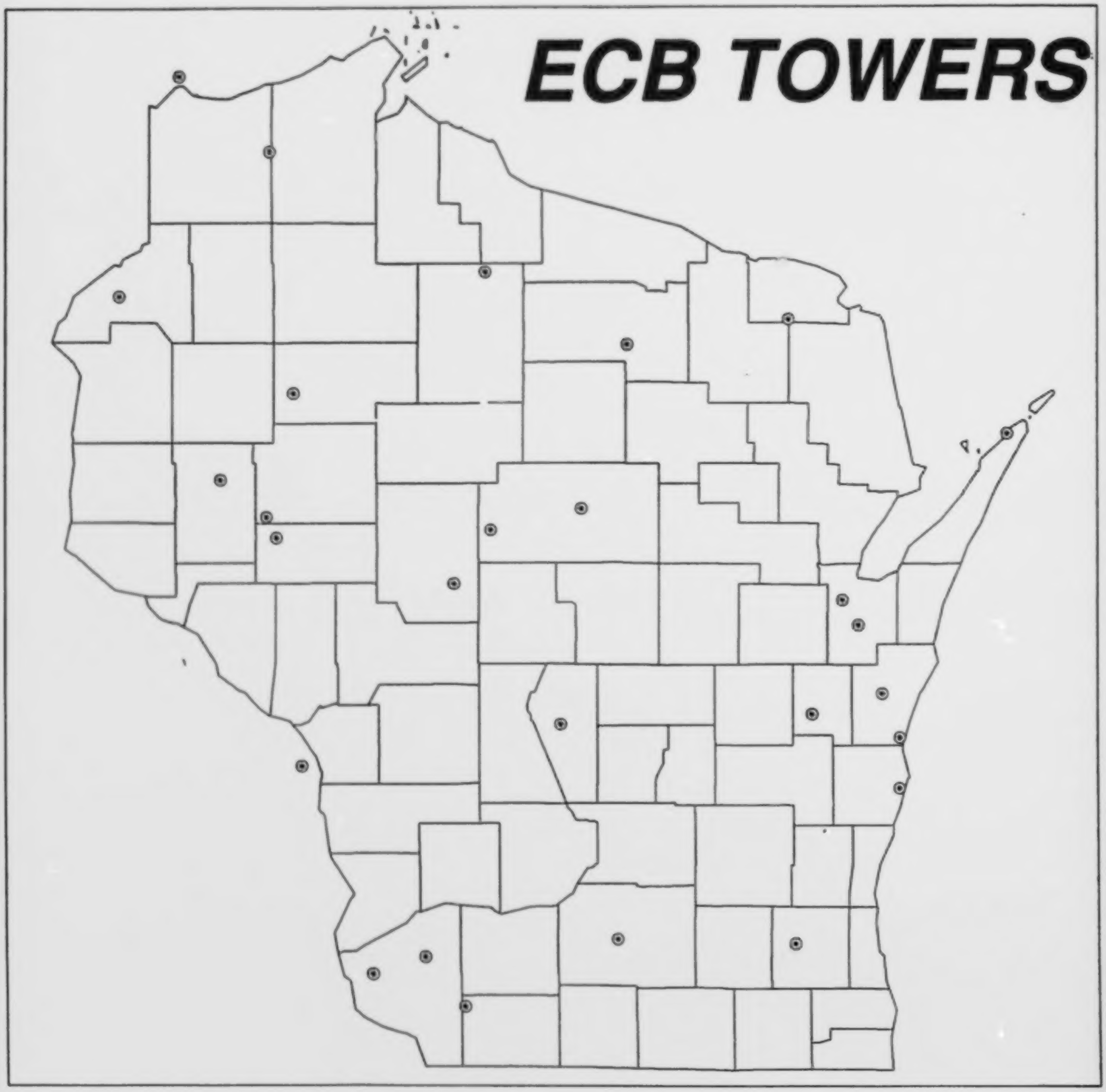
TOWER LOCATION LIST

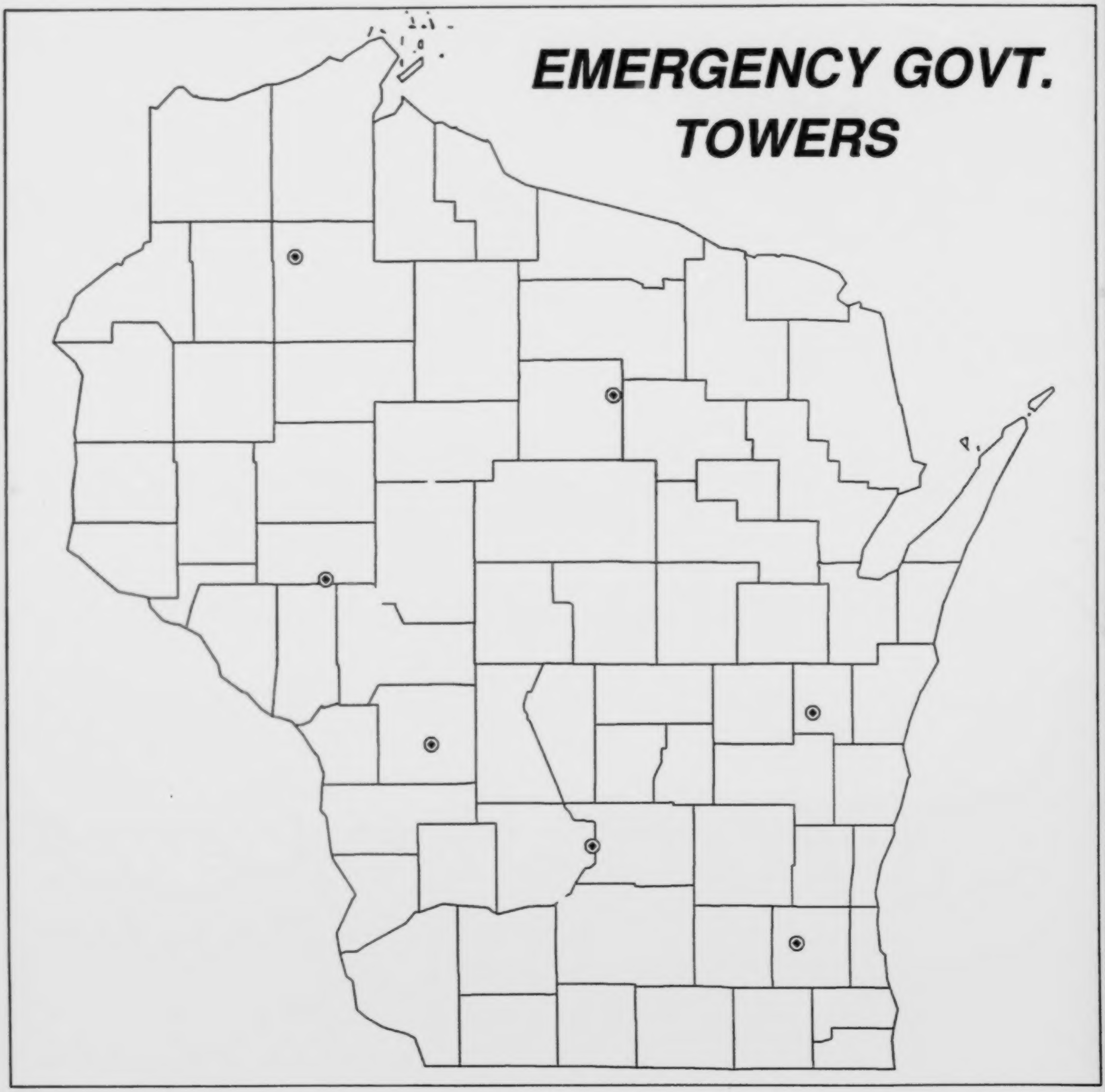
Appendix F-4

Agency		Site	Latitude			Longitude		
DOT SP	16	SQUIRREL	45	49	34	89	53	35
DOT SP	17	LAKEWOOD	45	24	16	88	21	11
DOT SP	18	FOOTVILLE	42	41	18	89	9	31
DOT SP	19	CARY MOUND	44	31	31	90	12	59
DOT SP	20	NECEDAH	44	1	22	90	4	20
DOT SP	21	LOOKOUT	45	24	3	89	28	55
DOT SP	22	SPOONER-D7	45	48	20	91	54	5
DOT SP	23	BENNETT	46	25	26	91	52	42
DOT SP	24	RED CLIFF	46	49	41	90	50	38
DOT SP	25	PARK FALLS	45	55	7	90	37	12
DOT SP	26	FREDERIC	45	38	16	92	25	18
DOT SP	27	HOLCOMBE	45	16	48	91	12	56
DOT SP	28	HAYWARD	46	0	10	91	24	32
DOT SP	29	METEOR	45	41	36	91	20	51
DOT SP	30	EAU	44	45	44	91	24	48
DOT SP	31	BALDWIN	44	58	11	92	19	10
DOT SP	32	NELSON	44	25	9	91	58	49
DOT SP	33	ELMWOOD	44	46	22	92	6	58
DOT SP	34	BLACK	44	22	30	90	50	30
DOT SP	35	OSSEO	44	36	53	91	13	47
DOT SP	36	TOMAH-D5	43	57	7	90	31	3
DOT SP	37	RIDGEVILLE	43	53	44	90	35	0
DOT SP	38	ASHRIDGE	43	29	56	90	32	28
DOT SP	39	LA	43	48	17	91	22	6
DOT SP	40	SENECA	43	16	7	90	59	1
DOT SP	41	MADISON-D1	43	8	11	89	17	44
DOT SP	41	MADISON-D1	43	11	35	89	20	18
DOT SP	42	HILL FARMS	43	4	25	89	27	36
DOT SP	43	DEERFIELD	43	2	44	89	6	4
DOT SP	44	BLUE	43	1	35	89	51	14
DOT SP	45	NEDA	43	26	6	88	31	36
DOT SP	46	BARABOO	43	27	22	89	37	0
DOT SP	47	KIELER	42	31	43	90	36	56
DOT SP	48	UNION	42	41	40	88	5	5
DOT SP	49	MERCER	46	14	23	90	9	4
DOT SP	50	IRON RIVER	46	32	49	91	24	50
DOT SP	51	WAUPACA	44	26	52	89	4	40
DOT SP	52	LA	43	48	16	91	22	18
DOT SP	53	ACADEMY	44	1	52	90	39	50
DOT SP	54	ST CROIX	44	53	10	92	39	28
DOT SP	55	CHIPPEWA	45	1	0	91	33	46
DOT SP	56	SHELL LAKE	45	45	58	91	50	49
DEG		BARABOO	43	27	22	89	37	0
DEG		DELAFIELD	43	01	56	88	23	31
DEG		CHILTON	44	01	42	88	17	08
DEG		LOOKOUT	45	24	03	89	28	55
DEG		RIDGEVILLE	43	53	44	90	35	00
DEG		OSSEO	44	36	53	91	13	47
DEG		HAYWARD	46	00	10	91	24	32

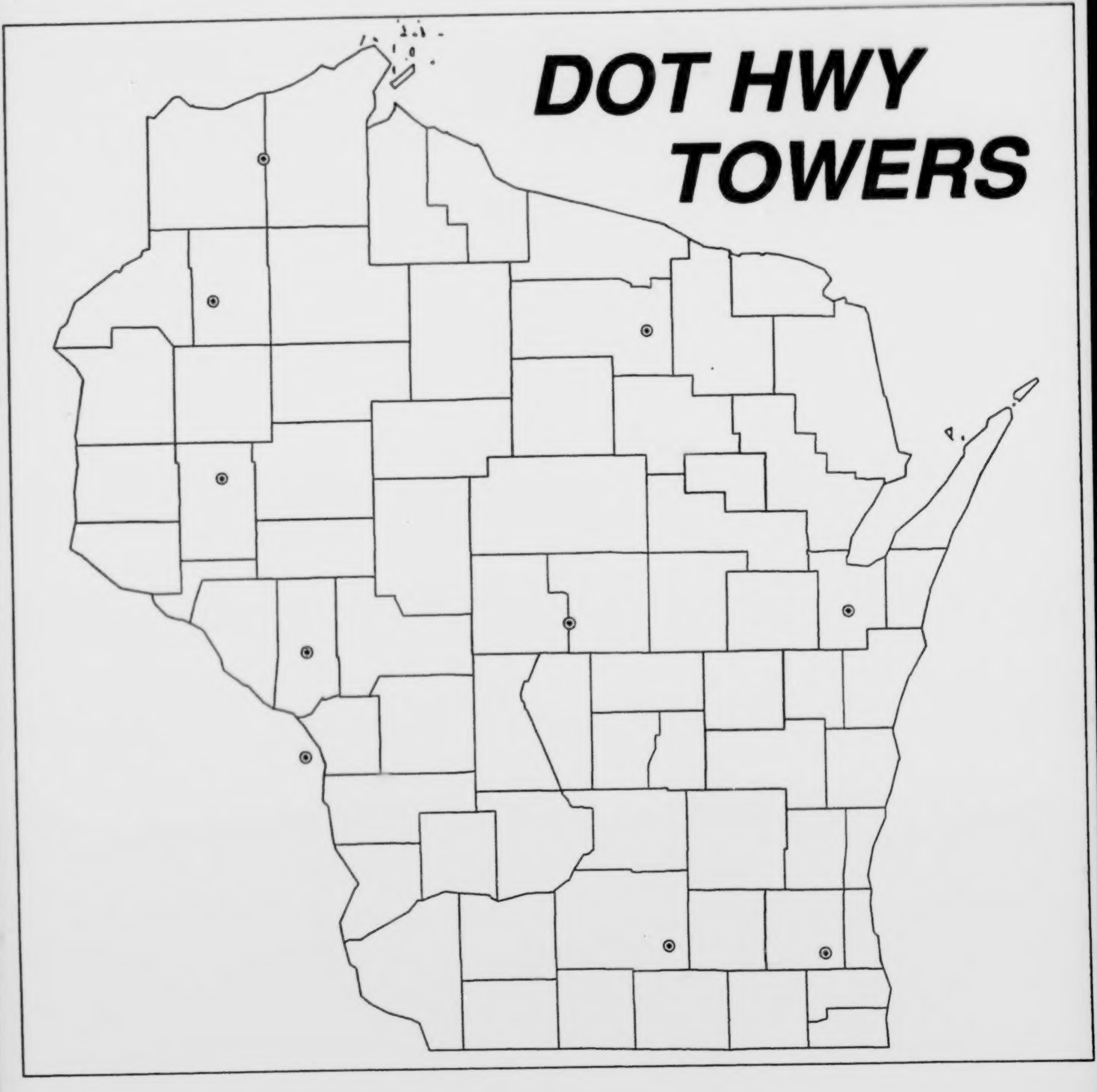

DNR TOWERS

ECB TOWERS



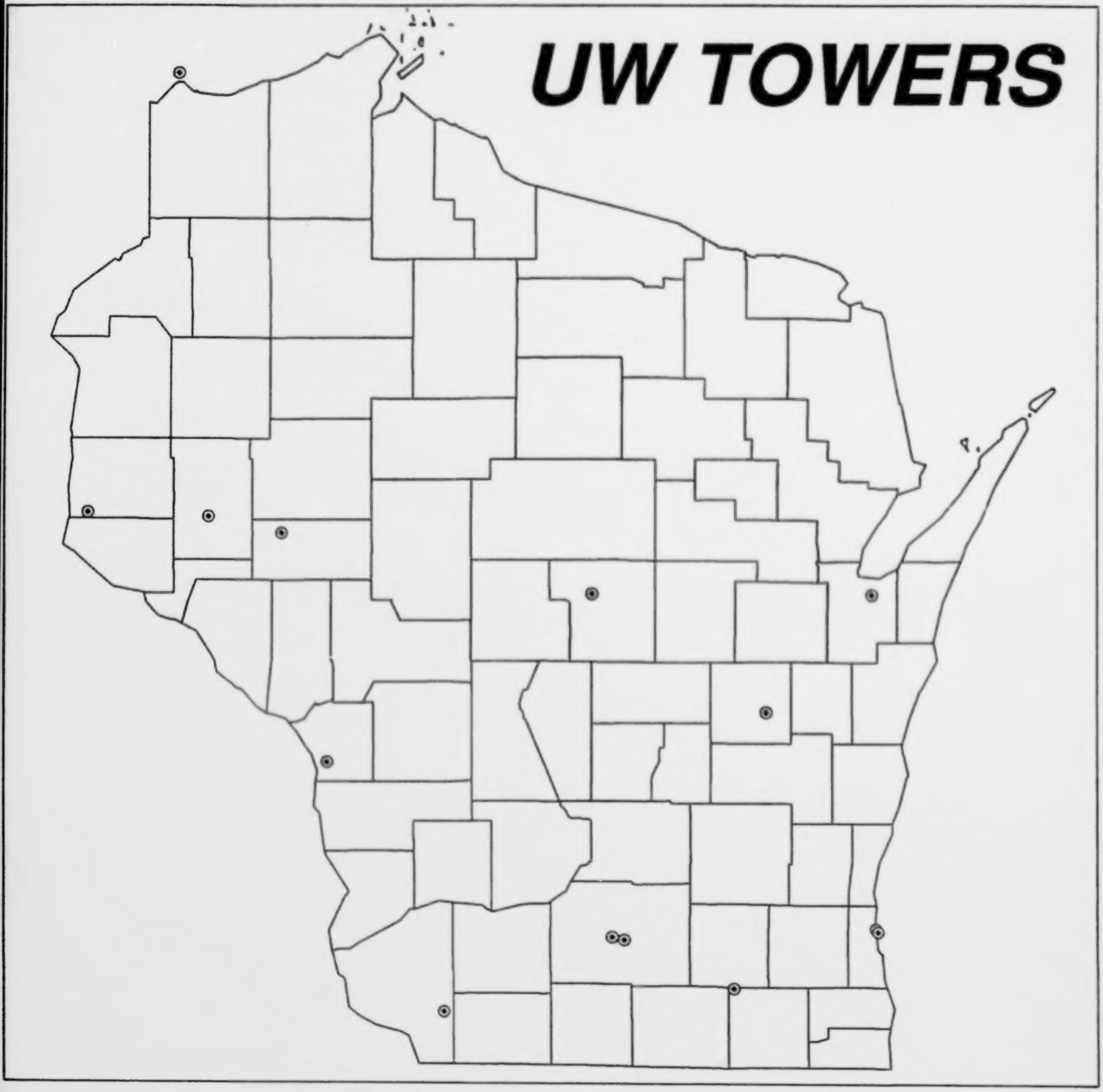


EMERGENCY GOVT. TOWERS


DOT HWY TOWERS

APPENDIX F-9

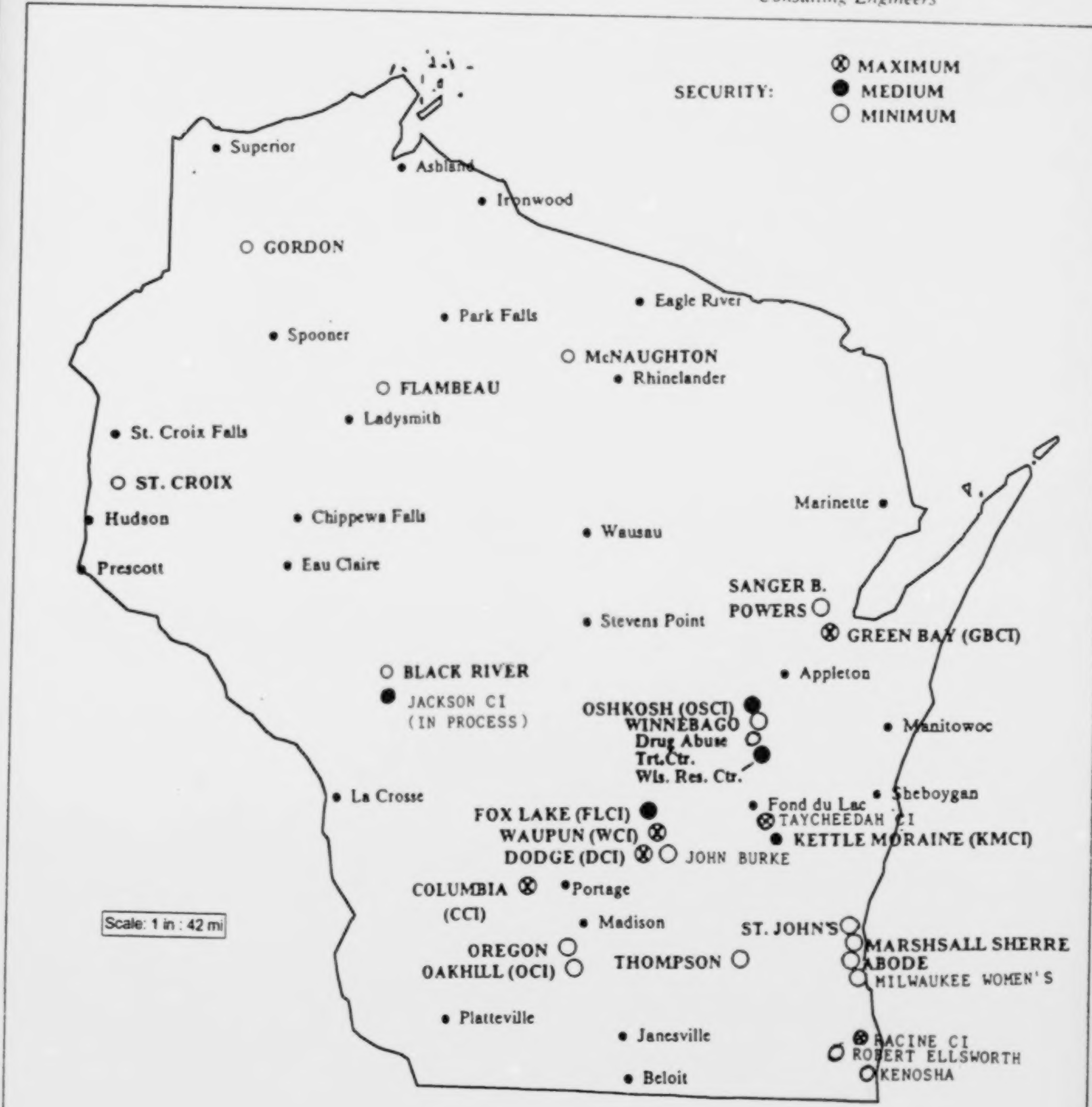
UW TOWERS



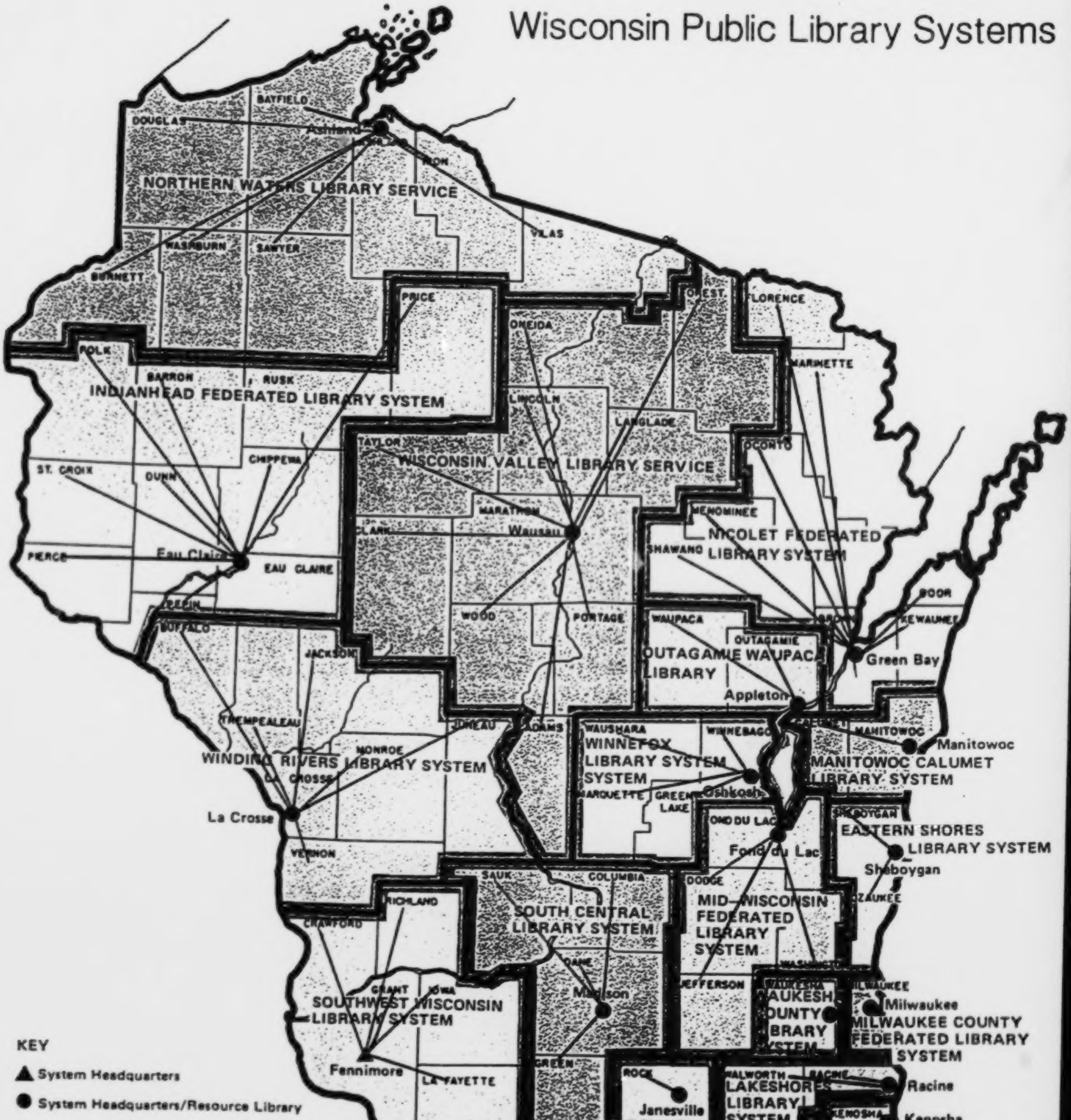
Appendix G-1

WISCONSIN CORRECTIONAL INSTITUTIONS

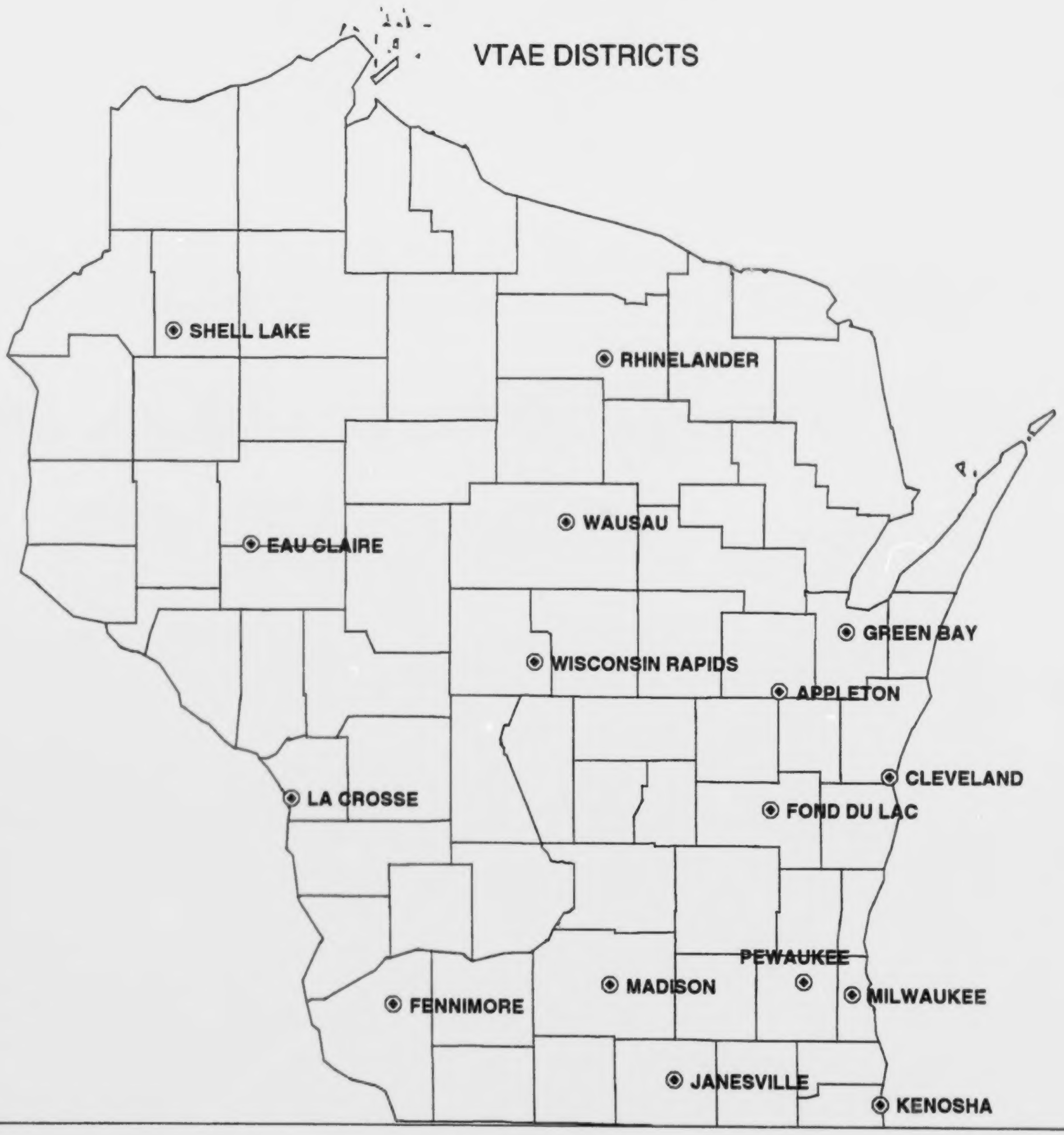
EVANS ASSOCIATES
Consulting Engineers

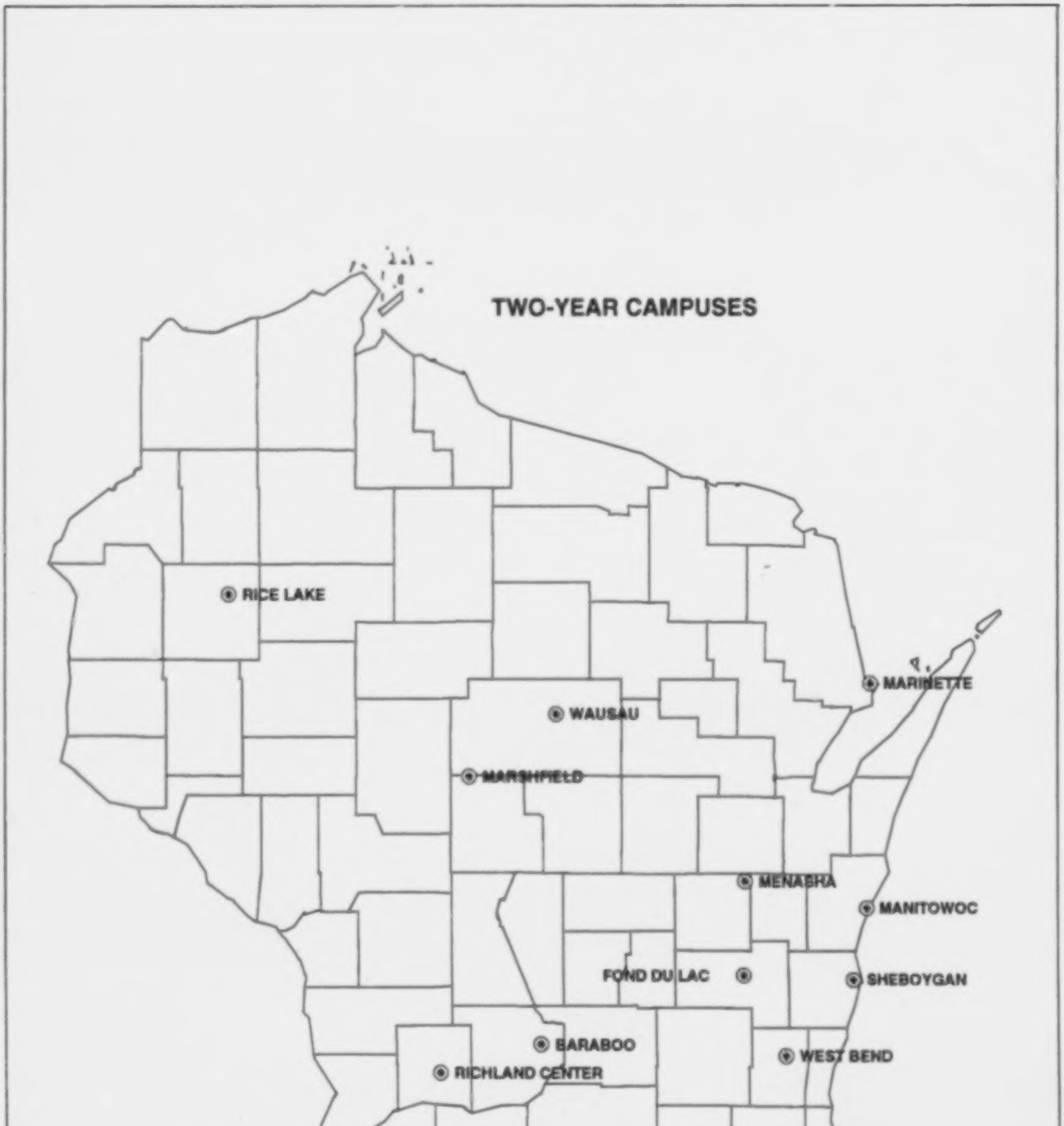

SECURITY:
⊗ MAXIMUM
● MEDIUM
○ MINIMUM
Superior
Ashland
Ironwood
GORDON
Eagle River
Park Falls
Spooner
McNAUGHTON
Rhinelander
FLAMBEAU
Ladysmith
St. Croix Falls
ST. CROIX
Hudson
Chippewa Falls
Marinette
Wausau
Prescott
Eau Claire
SANGER B. POWERS
Stevens Point
GREEN BAY (GBCI)
BLACK RIVER
Appleton
JACKSON CI (IN PROCESS)
OSHKOSH (OSCI)
WINNEBAGO
Drug Abuse Trt.Ctr.
Wis. Res. Ctr.
Manitowoc
La Crosse
Sheboygan
Fond du Lac
FOX LAKE (FLCI)
TAYCHEEDAH CI
WAUPUN (WCI)
KETTLE MORAINE (KMCI)
DODGE (DCI)
JOHN BURKE
COLUMBIA (CCI)
Portage
Scale: 1 in : 42 mi
Madison
ST. JOHN'S
MARSHSALL SHERRE
OREGON
ABODE
THOMPSON
OAKHILL (OCI)
MILWAUKEE WOMEN'S
Platteville
Janesville
RACINE CI
ROBERT ELLSWORTH
Beloit
KENOSHA

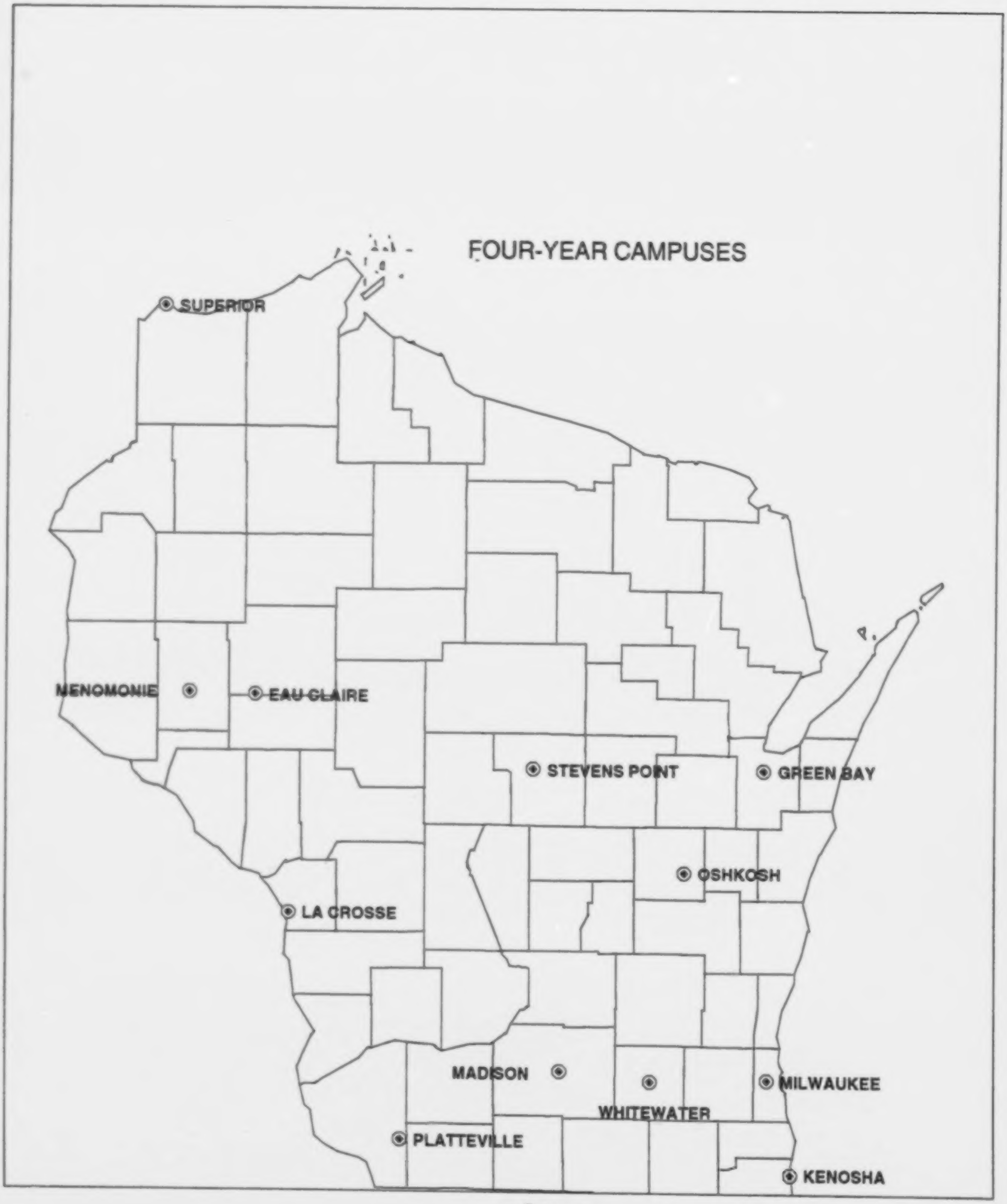
Wisconsin Public Library Systems


DOUGLAS
BAYFIELD
Ashland
IRON
NORTHERN WATERS LIBRARY SERVICE
VILAS
WASHBURN
SAWYER
BURNETT
PRICE
FOREST
FLORENCE
POLK
BARRON
RUSK
INDIANHEAD FEDERATED LIBRARY SYSTEM
ONEIDA
MARINETTE
LINCOLN
LANGLADE
TAYLOR
OCONTO
WISCONSIN VALLEY LIBRARY SERVICE
ST. CROIX
DUNN
CHIPPEWA
MARATHON
MENOMINEE
CLARK
Wausau
NICOLET FEDERATED LIBRARY SYSTEM
SHAWANO
PIERCE
Eau Claire
EAU CLAIRE
PEPIN
DOOR
BROWN
KEWAUNEE
WOOD
PORTAGE
WAUPACA
BUFFALO
OUTAGAMIE
JACKSON
OUTAGAMIE WAUPACA LIBRARY
Green Bay
Appleton
TREMPEALEAU
JUNEAU
ADAMS
WAUSHARA
WINNEBAGO
CALUMET
MANITOWOC
Manitowoc
MONROE
WINNEFOX LIBRARY SYSTEM SYSTEM
MANITOWOC CALUMET LIBRARY SYSTEM
WINDING RIVERS LIBRARY SYSTEM
LA CROSSE
MARQUETTE
GREEN LAKE
Oshkosh
La Crosse
FOND DU LAC
SHEBOYGAN
EASTERN SHORES LIBRARY SYSTEM
Fond du Lac
VERNON
Sheboygan
SAUK
COLUMBIA
DODGE
OZAUKEE
RICHLAND
SOUTH CENTRAL LIBRARY SYSTEM
MID-WISCONSIN FEDERATED LIBRARY SYSTEM
CRAWFORD
WASHINGTON
DANE
GRANT
IOWA
JEFFERSON
WAUKESHA
MILWAUKEE
Madison
Milwaukee
SOUTHWEST WISCONSIN LIBRARY SYSTEM
WAUKESHA COUNTY LIBRARY SYSTEM
MILWAUKEE COUNTY FEDERATED LIBRARY SYSTEM
KEY
▲ System Headquarters
● System Headquarters/Resource Library
Fennimore
LAFAYETTE
GREEN
ROCK
WALWORTH
RACINE
Racine
Janesville
LAKESHORES LIBRARY SYSTEM
KENOSHA
Kenosha
ARROWHEAD LIBRARY SYSTEM
KENOSHA COUNTY LIBRARY SYSTEM

BEST COPY AVAILABLE

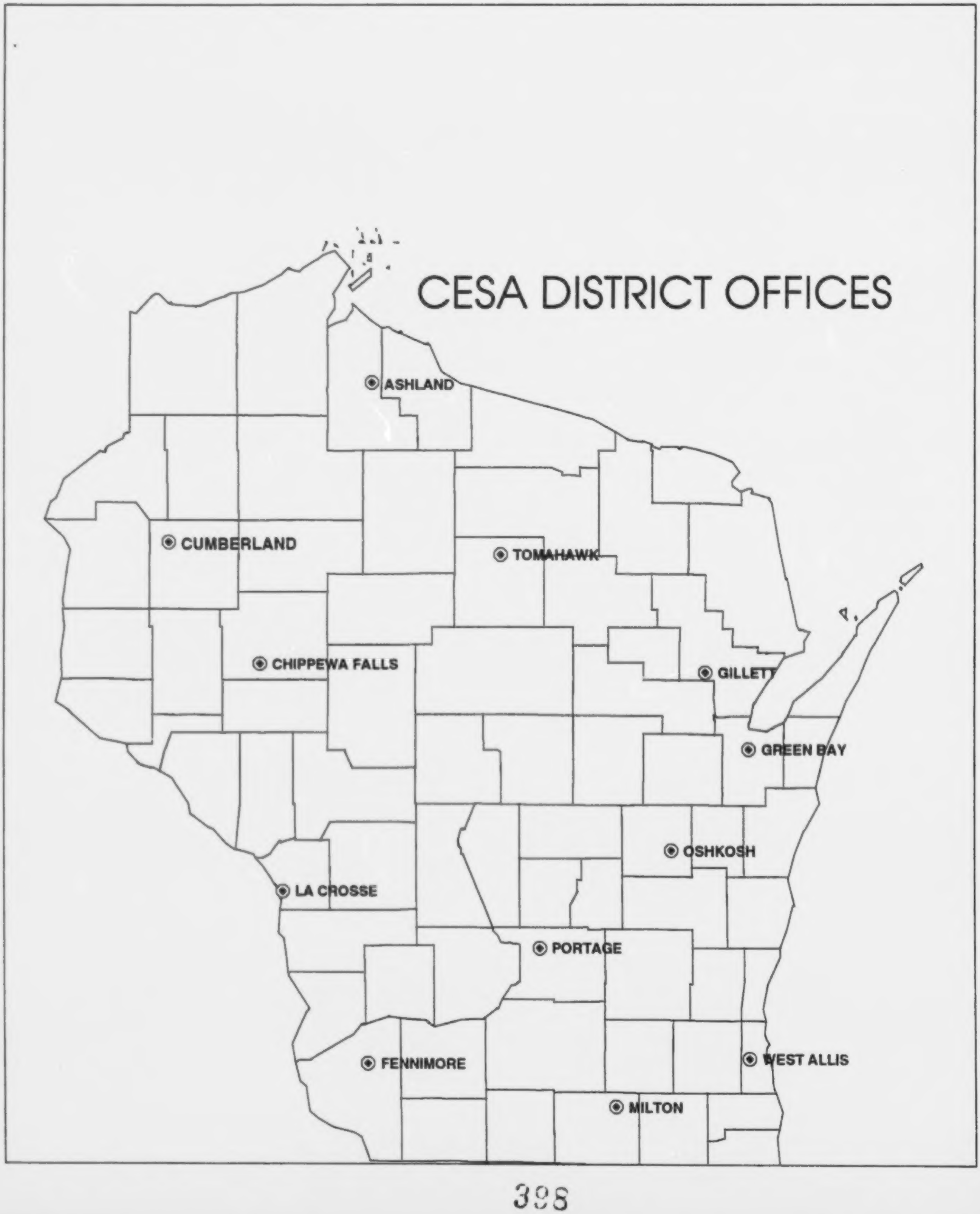

VTAE DISTRICTS
SHELL LAKE
RHINELANDER
WAUSAU
EAU CLAIRE
GREEN BAY
WISCONSIN RAPIDS
APPLETON
CLEVELAND
LA CROSSE
FOND DU LAC
PEWAUKEE
MADISON
MILWAUKEE
FENNIMORE
JANESVILLE
KENOSHA


TWO-YEAR CAMPUSES
RICE LAKE
MARINETTE
WAUSAU
MARSHFIELD
MENASHA
MANITOWOC
FOND DU LAC
SHEBOYGAN
BARABOO
RICHLAND CENTER
WEST BEND
WAUKESHA
JANESVILLE

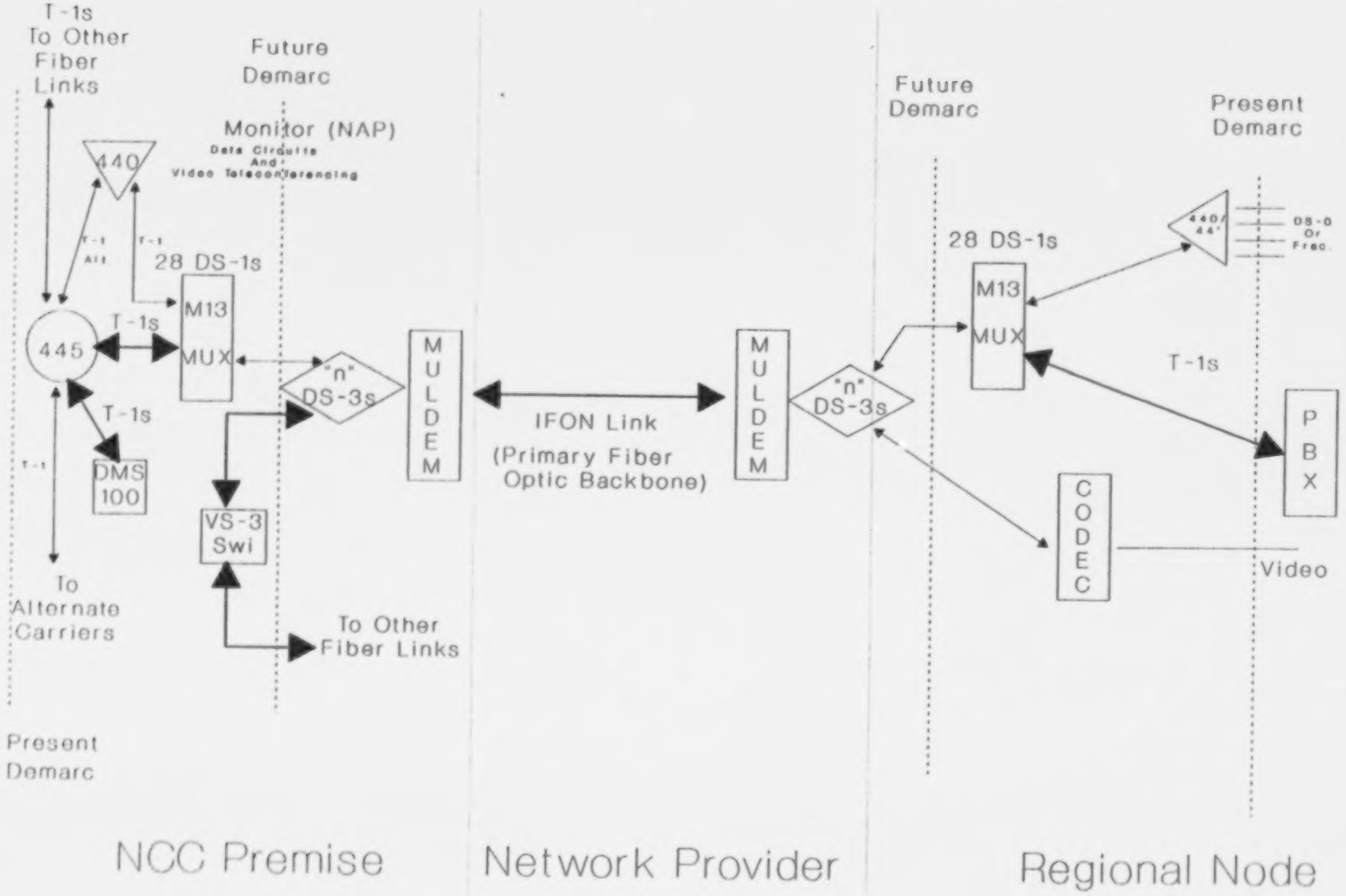


FOUR-YEAR CAMPUSES

SUPERIOR
MENOMONIE
EAU CLAIRE
STEVENS POINT
GREEN BAY
OSHKOSH
LA CROSSE
MADISON
WHITEWATER
MILWAUKEE
PLATTEVILLE
KENOSHA


CESA DISTRICT OFFICES
ASHLAND
CUMBERLAND
TOMAHAWK
CHIPPEWA FALLS
GILLETT
GREEN BAY
OSHKOSH
LA CROSSE
PORTAGE
FENNIMORE
WEST ALLIS
MILTON

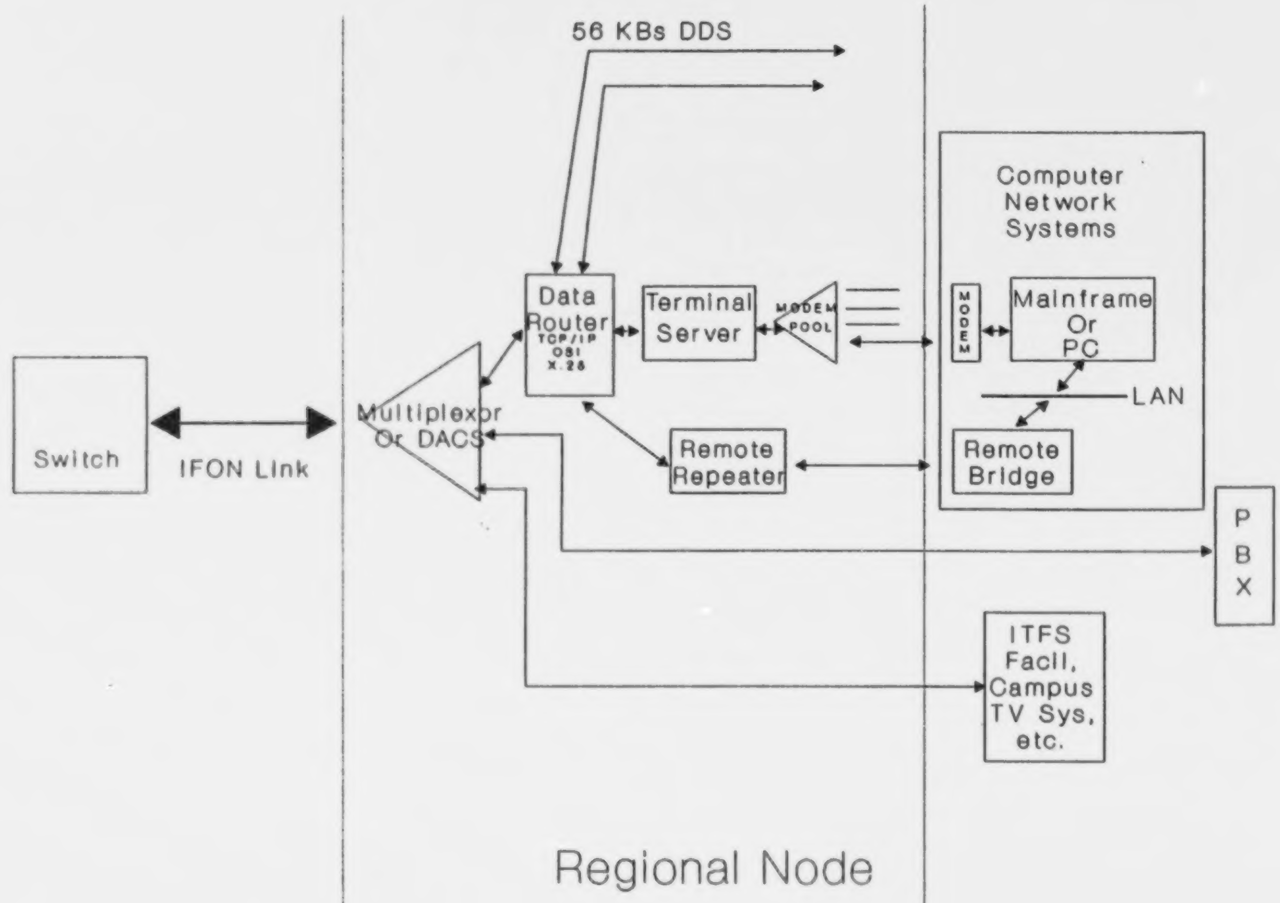
System Study: Network Connections


T-1s
To Other
Fiber
Links
Future
Demarc
Monitor (NAP)
Data Circuits
And
Video Teleconferencing
440
T-1
Alt
T-1
28 DS-1s
M13
MUX
445
T-1s
T-1s
DMS
100
T-1
"n"
DS-3s
VS-3
Swi
To
Alternate
Carriers
To Other
Fiber Links
Present
Demarc
M
U
L
D
E
M
IFON Link
(Primary Fiber
Optic Backbone)
M
U
L
D
E
M
"n"
DS-3s
Future
Demarc
Present
Demarc
28 DS-1s
M13
MUX
440/
44'
DS-0
Or
Frac.
T-1s
P
B
X
C
O
D
E
C
Video
NCC Premise
Network Provider
Regional Node

Evans Associates

APPENDIX M-1

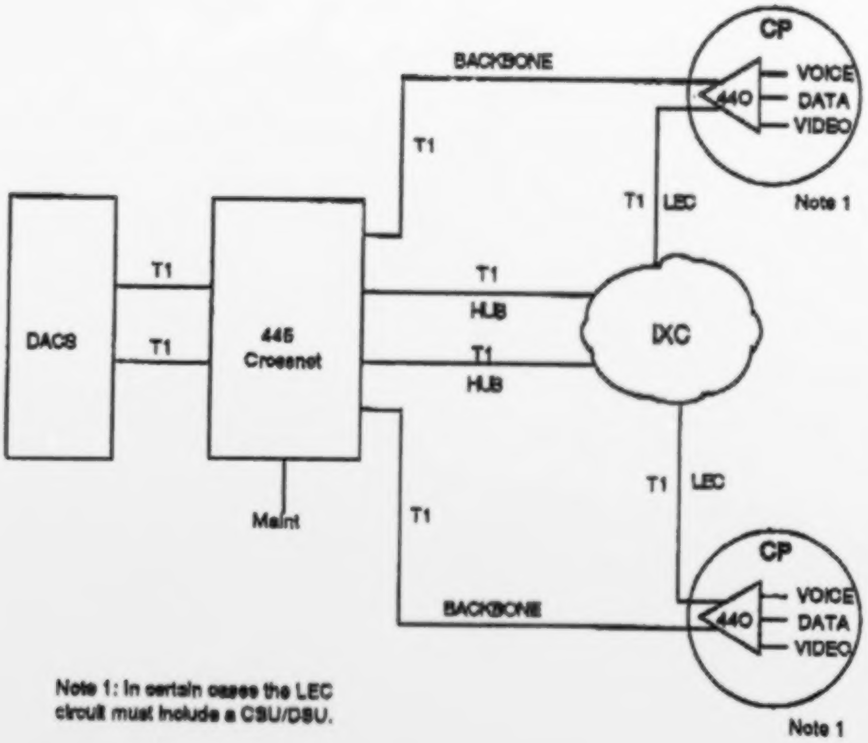
System Study: Network Connections


56 KBs DDS
Computer
Network
Systems
Data
Router
TCP/IP
OSI
X.25
Terminal
Server
MODEM
POOL
MODEM
Mainframe
Or
PC
LAN
Switch
IFON Link
Multiplexor
Or DACS
Remote
Repeater
Remote
Bridge
P
B
X
ITFS
Facil,
Campus
TV Sys,
etc.
Regional Node

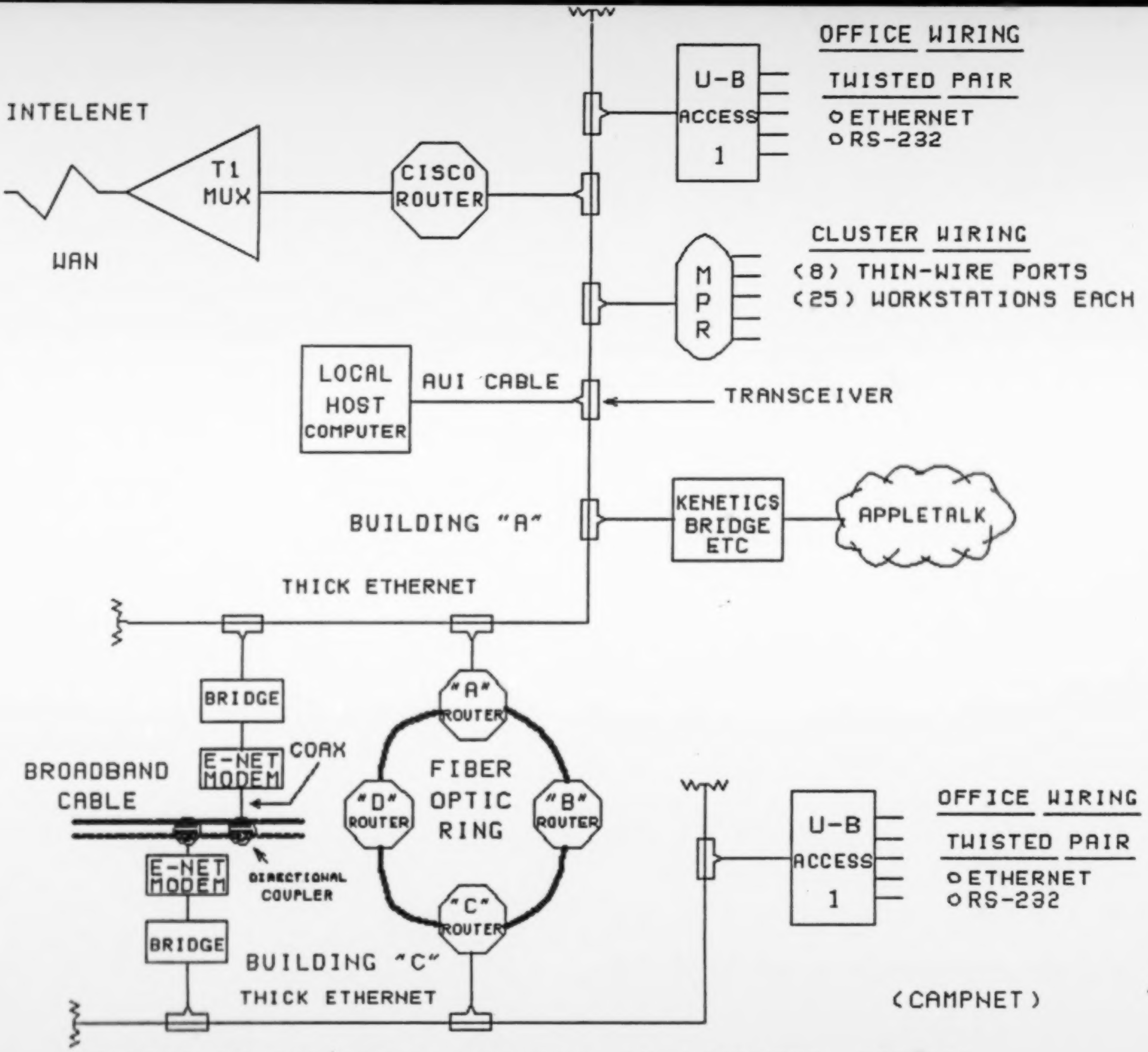
Evans Associates

ALTERNATE ROUTING
FROM
MULTIPLEXER

OCTOBER 15,1990


CP
BACKBONE
440
VOICE
DATA
VIDEO
T1
T1
LEC
Note 1
DACS
T1
T1
445
Crossnet
T1
HUB
T1
HUB
IXC
Maint
T1
T1
LEC
CP
BACKBONE
440
VOICE
DATA
VIDEO
Note 1

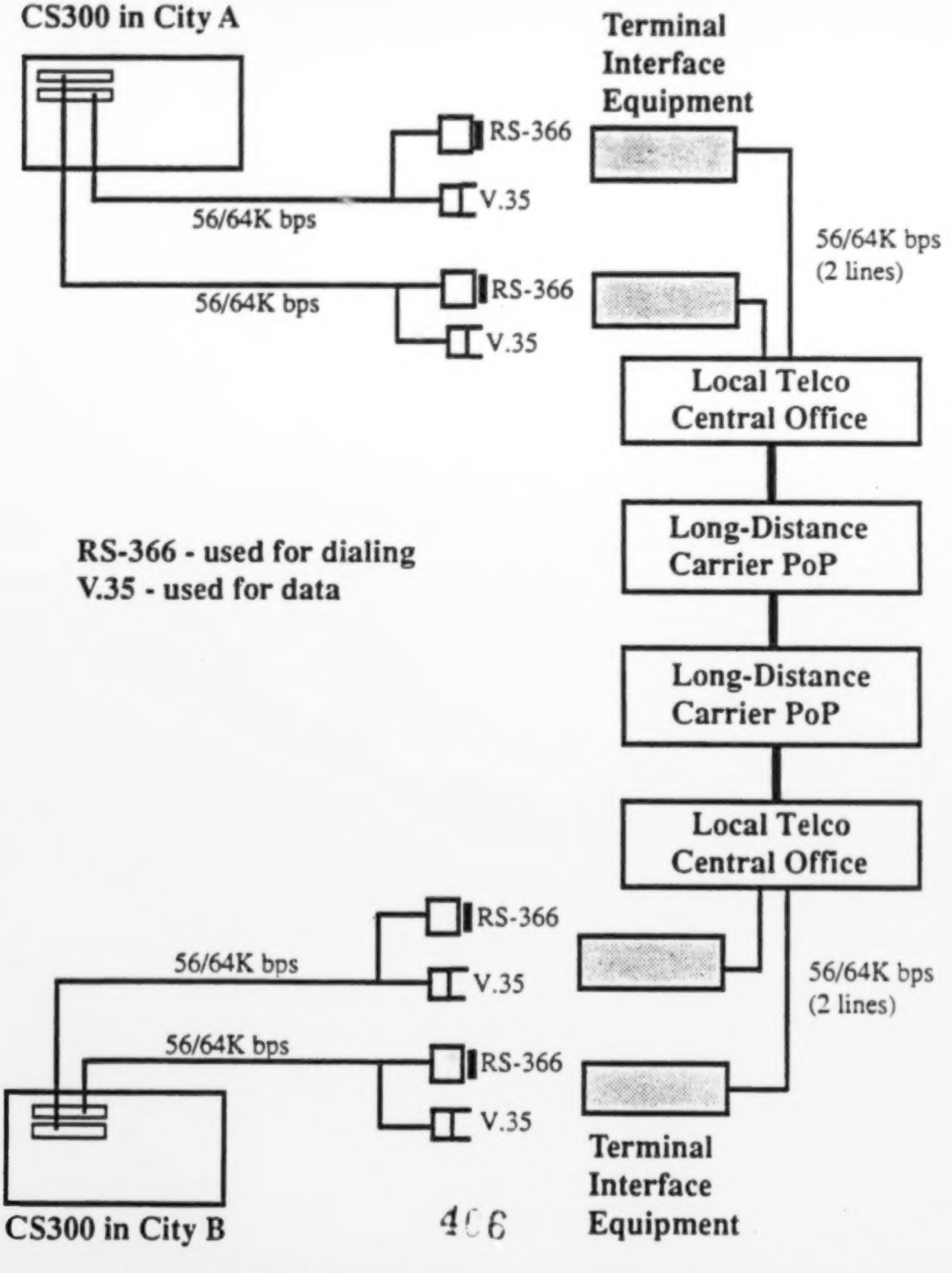
Note 1: In certain cases the LEC circuit must include a CSU/DSU.


OFFICE WIRING
TWISTED PAIR
○ ETHERNET
○ RS-232
U-B ACCESS 1
INTELENET
T1 MUX
CISCO ROUTER
WAN
CLUSTER WIRING
(8) THIN-WIRE PORTS
(25) WORKSTATIONS EACH
MPR
LOCAL HOST COMPUTER
AUI CABLE
TRANSCEIVER
KENETICS BRIDGE ETC
APPLETALK
BUILDING "A"
THICK ETHERNET
BRIDGE
E-NET MODEM
COAX
BROADBAND CABLE
DIRECTIONAL COUPLER
E-NET MODEM
BRIDGE
"A" ROUTER
FIBER OPTIC RING
"D" ROUTER
"B" ROUTER
"C" ROUTER
OFFICE WIRING
TWISTED PAIR
○ ETHERNET
○ RS-232
U-B ACCESS 1
BUILDING "C"
THICK ETHERNET

(CAMPNET)

GENERIC CAMPUS TCP/IP NETWORK (M.J.ENYEART, 2/6/89)

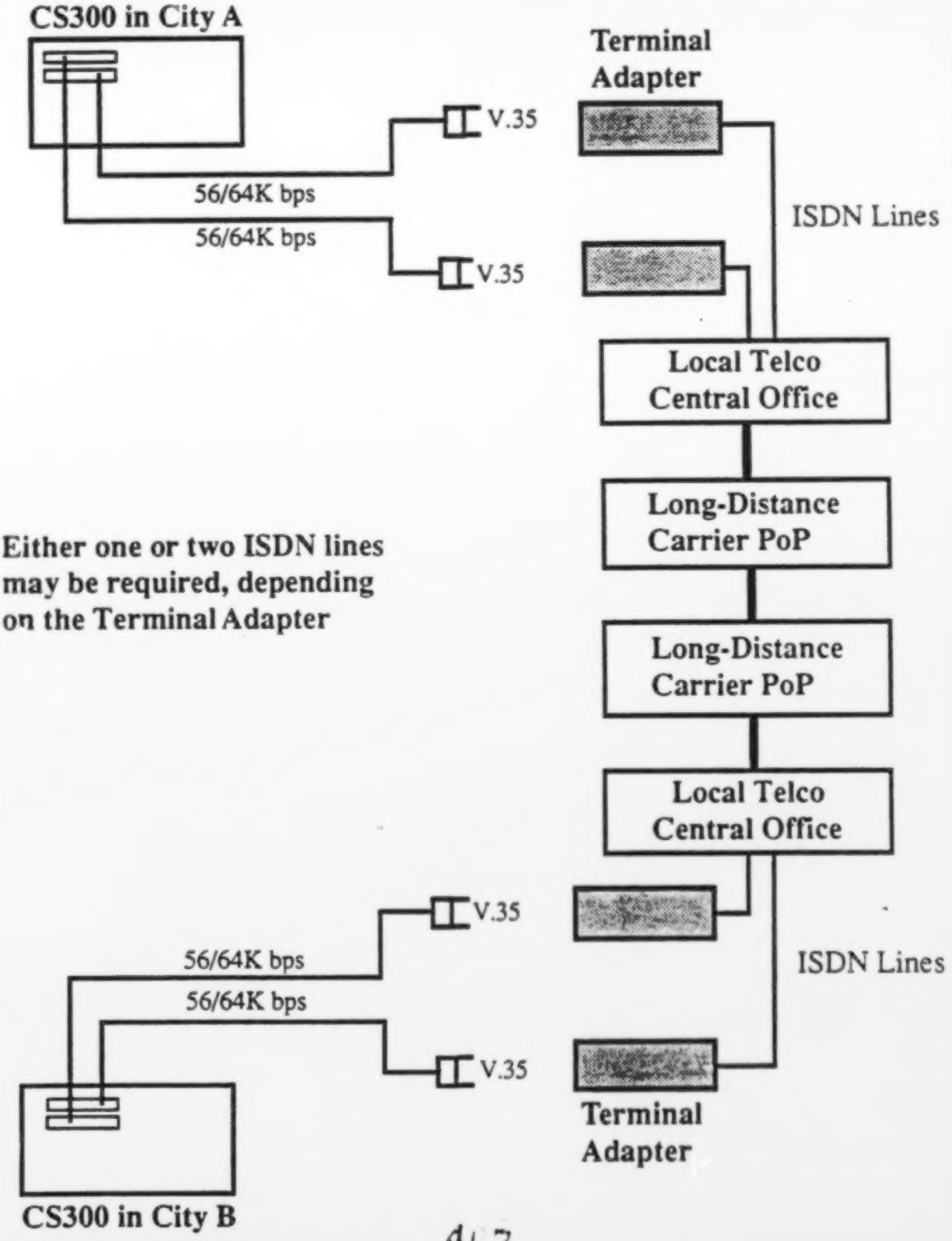
System Network Components
Dual Switched 56 Network


CS300 in City A
Terminal Interface Equipment
RS-366
V.35
56/64K bps
56/64K bps
RS-366
V.35
56/64K bps (2 lines)
Local Telco Central Office
Long-Distance Carrier PoP
Long-Distance Carrier PoP
Local Telco Central Office
RS-366
56/64K bps
V.35
56/64K bps (2 lines)
56/64K bps
RS-366
V.35
Terminal Interface Equipment
CS300 in City B

RS-366 - used for dialing
V.35 - used for data

Courtesy: VideoTelecom

System Network Components
ISDN Network



CS300 in City A

Terminal Adapter

V.35

56/64K bps

56/64K bps

V.35

ISDN Lines

Local Telco Central Office

Long-Distance Carrier PoP

Long-Distance Carrier PoP

Local Telco Central Office

V.35

56/64K bps

56/64K bps

V.35

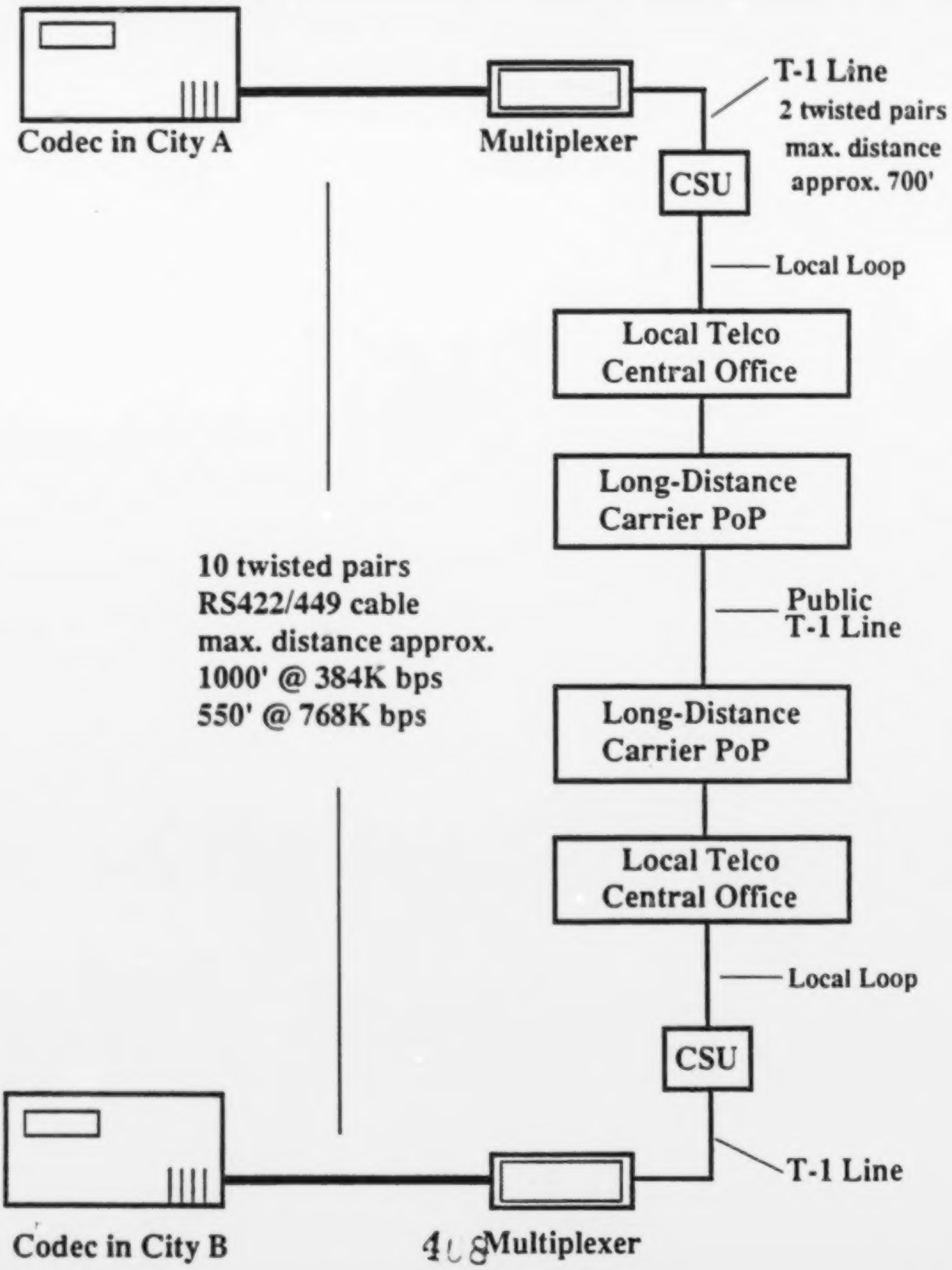
ISDN Lines

Terminal Adapter

CS300 in City B

Either one or two ISDN lines may be required, depending on the Terminal Adapter

System Network Components
Public T-1 Network



Codec in City A

Multiplexer

T-1 Line
2 twisted pairs
max. distance
approx. 700'

CSU

Local Loop

Local Telco
Central Office

Long-Distance
Carrier PoP

10 twisted pairs
RS422/449 cable
max. distance approx.
1000' @ 384K bps
550' @ 768K bps

Public
T-1 Line

Long-Distance
Carrier PoP

Local Telco
Central Office

Local Loop

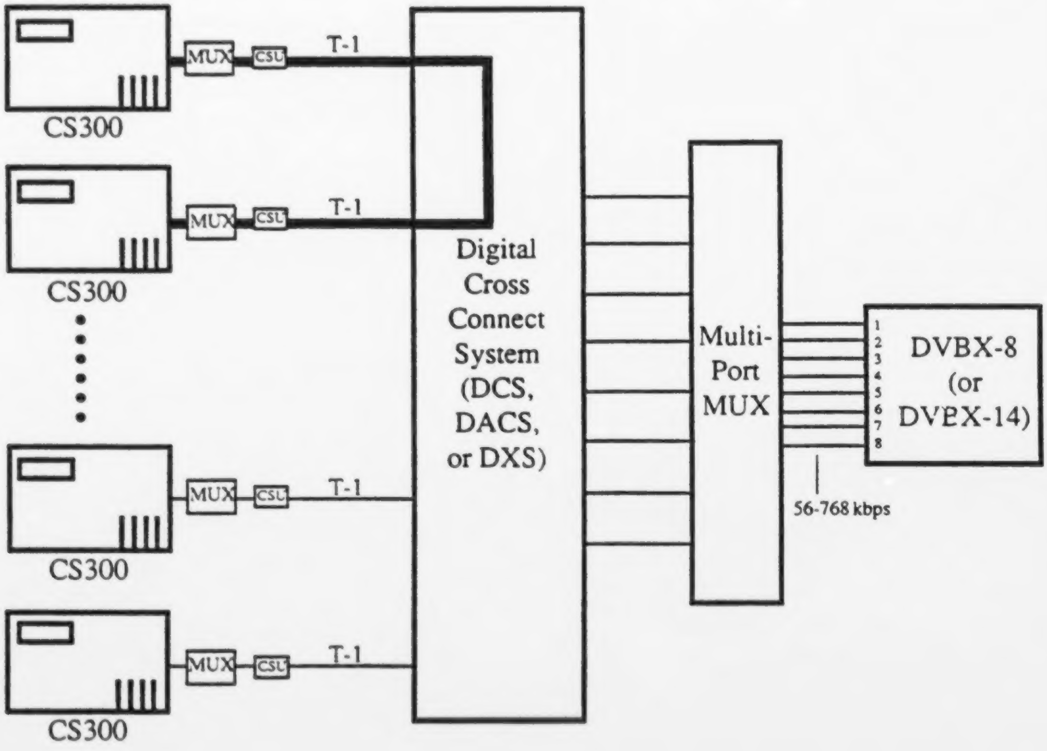
CSU

T-1 Line

Codec in City B

Multiplexer

Setting Up a Point-to-Point Videoconference Using a Digital Cross Connect System

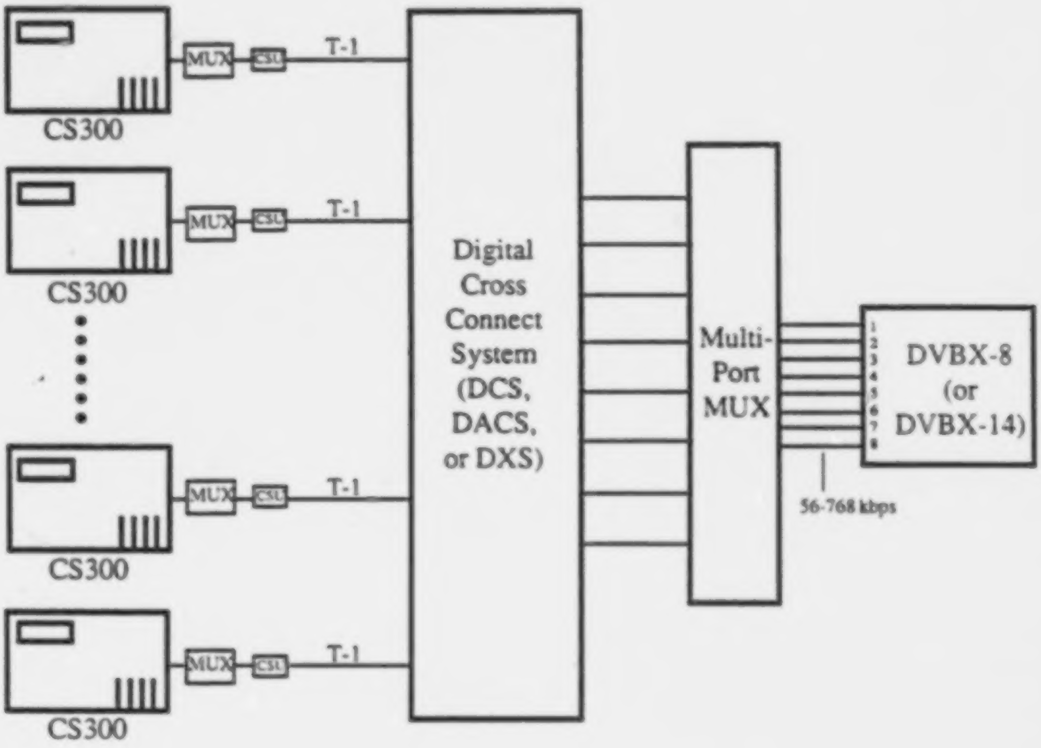

MUX
CSU
T-1
CS300
MUX
CSU
T-1
CS300
MUX
CSU
T-1
CS300
MUX
CSU
T-1
CS300
Digital Cross Connect System (DCS, DACS, or DXS)
Multi-Port MUX
1
2
3
4
5
6
7
8
DVBX-8 (or DVBX-14)
56-768 kbps

A point-to-point videoconference can be set up by connecting two codecs directly at the Digital Cross Connect System. This allows the point-to-point conference to retain all of the functions available through the CS300

In the example above, the first and second codecs are connected in a two-way call

Courtesy: VideoTelecom

Configuring a Videoconferencing Network Using a Digital Cross Connect System


CS300
MUX
CSU
T-1
CS300
MUX
CSU
T-1
CS300
MUX
CSU
T-1
CS300
MUX
CSU
T-1
Digital Cross Connect System (DCS, DACS, or DXS)
Multi-Port MUX
1
2
3
4
5
6
7
8
DVBX-8 (or DVBX-14)
56-768 kbps

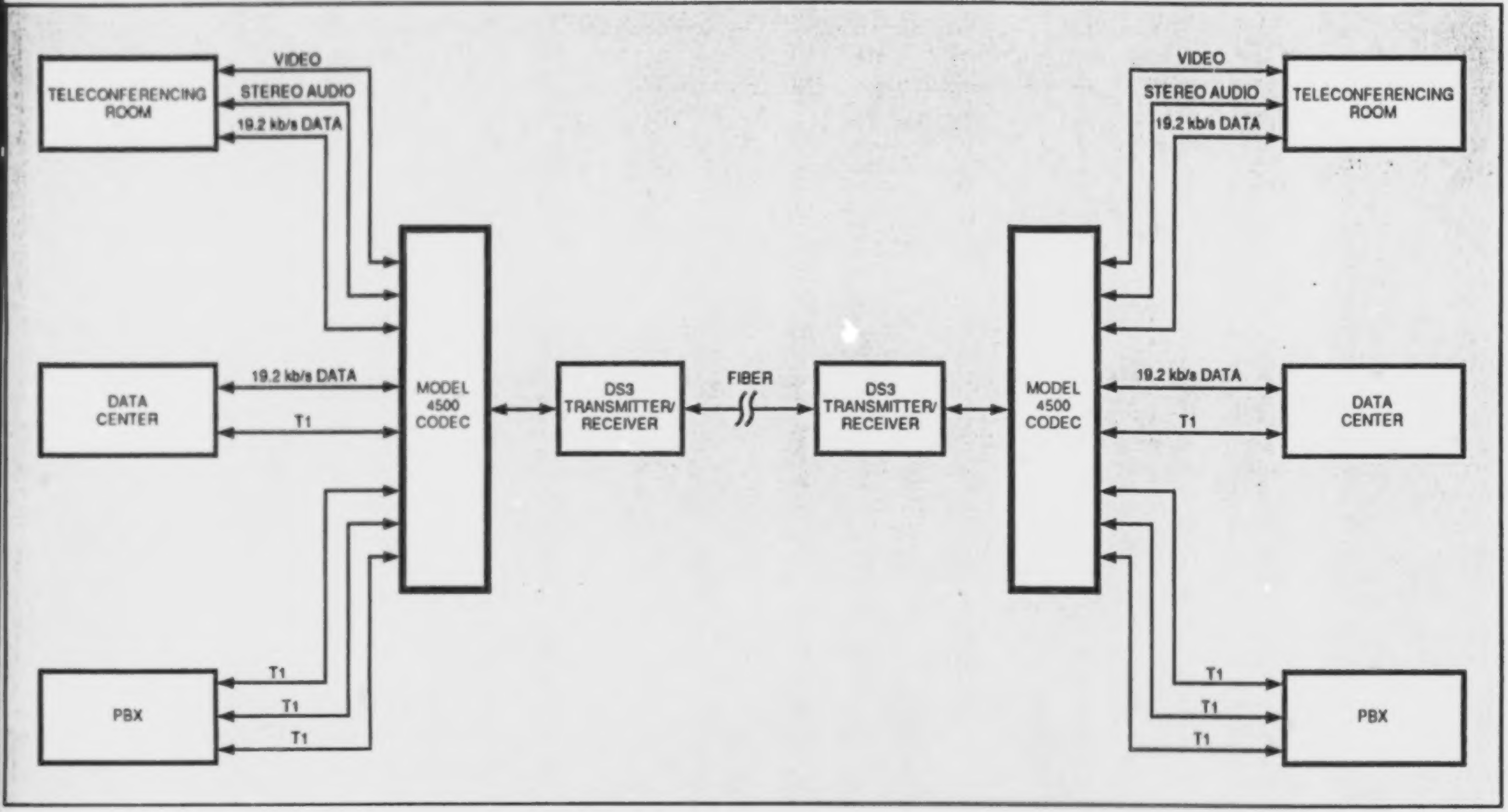
By placing a Digital Cross Connect System between the DVBX and the network connections to remote codecs, the user can set up multiway conferences or point-to-point conferences as needed

This configuration allows for more than 14 codecs to share a DVBX

Courtesy: VideoTelecom

DS3 Video Conferencing System

(Full Duplex)


TELECONFERENCING ROOM
VIDEO
STEREO AUDIO
19.2 kb/s DATA
DATA CENTER
19.2 kb/s DATA
T1
PBX
T1
T1
T1
MODEL 4500 CODEC
DS3 TRANSMITTER/ RECEIVER
FIBER
DS3 TRANSMITTER/ RECEIVER
MODEL 4500 CODEC
VIDEO
STEREO AUDIO
19.2 kb/s DATA
TELECONFERENCING ROOM
19.2 kb/s DATA
T1
DATA CENTER
T1
T1
T1
PBX

BEST COPY AVAILABLE

Courtesy: Grass Valley Group

MIGRATION PLAN

Below are listed various interconnection paths and their methods of establishment.

A. Items 1-9 list the paths of the MRC Digital Message Network and possibilities for interconnection.

1. Milwaukee (WMVS-TV) <--> Elkhorn (WHAD-FM)

    a. MRC Microwave

2. Milwaukee (WMVS-TV) <--> Madison (WHA-TV/FM)

    a. MRC Fiber (via Chicago)
    b. MCI Fiber
    c. MRC Microwave
    d. State Patrol Microwave

3. Milwaukee (WMVS-TV) <--> DePere (WNPE)

    a. MRC Microwave
    b. State Patrol Microwave (possibly)

4. Milwaukee (WMVS-TV) <--> Appleton (WLFM)

    a. MRC Fiber
    b. MCI Fiber
    c. MRC Microwave

5. Milwaukee (WMVS-TV) <--> Green Bay (WNPE-TV/FM, WBGW-FM)

    All Paths use Appleton to arrive at Green Bay.

    a. MRC Fiber
    b. MCI Fiber
    c. MRC Microwave

6. Milwaukee (WMVS-TV) <--> LaCrosse (WHLA-TV/FM)

    a. MRC Fiber (via Chicago)
    b. MCI Fiber (via Madison)
    c. MRC Microwave - planned
    d. State Patrol Microwave

7A. Milwaukee (WMVS-TV) <--> Wausau (WHRM-FM)

- a. MCI Fiber

7B. Madison (WHA-TV/FM) <--> Wausau (WHRM-FM)

- a. MRC Microwave
- b. State Patrol Microwave

8. Wausau (WHRM-FM) <--> Park Falls (WLEF-TV/FM)

- a. MRC Microwave
- b. State Patrol Microwave

9. Milwaukee (WMVS-TV) <--> WHWC-TV/FM

- a. MRC Microwave

B. Items 1-7 list the paths for the OC-12 part of the WODIE plan and possibilities for interconnection.

1. Milwaukee <--> Madison

- a. MCI Fiber

2. Milwaukee <--> Appleton

- a. MRC Fiber
- b. MCI Fiber

3. Madison <--> LaCrosse

- a. MCI Fiber

4. LaCrosse <--> Eau Claire

- a. MRC Fiber
- b. MRC Microwave
- c. State Patrol Microwave

5. Eau Claire <--> Wausau

- a. MCI Fiber
- b. Access Wisconsin (parts under construction)

6. Wausau <--> Appleton

    a. Access Wisconsin (parts under construction)

7. Madison <--> Appleton

    No direct path planned or under construction.

C. Items 1-10 list the paths for the 6-DS3 part of the WODIE plan and possibilities for interconnection.

1A. Milwaukee <--> Kenosha

    a. Access Wisconsin

1B. Milwaukee <--> Racine

    a. MRC Fiber
    b. MCI Fiber

2. Madison <--> Janesville

    a. MCI Fiber
    b. State Patrol Microwave

3. Madison <--> Fennimore

    a. Access Wisconsin (parts under construction)

4. Madison <--> Portage

    a. State Patrol Microwave

5. Eau Claire <--> Hudson

    a. MRC Fiber (possible)
    b. MRC Microwave
    c. State Patrol Microwave

6. Eau Claire <--> Rice Lake

    a. Access Wisconsin

7. Wausau <--> Rhinelander

    a. Access Wisconsin

8. Appleton <--> Green Bay
    a. MRC Fiber
    b. MCI Fiber
    c. MRC Microwave

9. Appleton <--> Cleveland

    No path planned or under construction at this time.

10. Appleton <--> Fond Du Lac

    No path planned or under construction at this time.

D. Items 1-58 list the paths for the 3-DS3 part of the WODIE plan and possibilities for interconnection.

1. New Richmond <--> Hudson
    a. State Patrol Microwave

2. River Falls <--> Hudson
    a. State Patrol Microwave

3. Superior <--> Hudson
    a. MCI Fiber

4. Ashland <--> Superior
    a. Access Wisconsin

5. Cumberland <--> Rice Lake
    a. Access Wisconsin

6. Shell Lake <--> Rice Lake
    a. Access Wisconsin - via Cumberland

7. Chippewa Falls <--> Eau Claire
    a. MRC Microwave
    b. State Patrol Microwave

8. Ladysmith <--> Eau Claire
    a. State Patrol Microwave

9. Menomonie <--> Eau Claire
    a. State Patrol Microwave

10. Black River Falls <--> La Crosse
    a. State Patrol Microwave

11. Sparta <--> La Crosse
    a. State Patrol Microwave

12. Tomah <--> La Crosse
    a. State Patrol Microwave

13. Independence <--> La Crosse
    a. MRC Microwave

14. Mauston <--> La Crosse
    a. Access Wisconsin - via Tomah (parts under construction)

15. Viroqua <--> La Crosse
    a. Access Wisconsin

16. Richland Center <--> Fennimore
    a. Access Wisconsin (parts under construction)

17. Platteville <--> Fennimore
    a. Access Wisconsin (parts under construction)

18. Minocqua <--> Rhinelander
    a. State Patrol Microwave

19. Tomahawk <--> Rhinelander
    a. Access Wisconsin

20. Park Falls <--> Phillips
    a. MRC Microwave

21. Phillips <--> Wausau
    a. MRC Microwave

22. Spencer <--> Marshfield
    a. MRC Microwave
    b. State Patrol Microwave

23. Marshfield <--> Wausau
    a. MRC Microwave
    b. State Patrol Microwave

24. Antigo <--> Wausau
    a. Access Wisconsin (parts under construction)

25. Medford <--> Wausau
    a. Access Wisconsin

26. Wittenberg <--> Wausau
    a. State Patrol Microwave

27. Stevens Point <--> Wausau
    a. MRC Microwave

28. Wisconsin Rapids <--> Wausau
    a. MRC Microwave

29. Reedsburg <--> Portage
    a. State Patrol Microwave

30. Baraboo <--> Portage

    a. State Patrol Microwave

31. Adams <--> Portage

    a. State Patrol Microwave

32. Monroe <--> Janesville

    a. Access Wisconsin (parts under construction)

33. Beloit <--> Janesville

    a. Access Wisconsin

34. Whitewater <--> Milton

    No path planned or under construction at this time.

35. Milton <--> Janesville

    a. Access Wisconsin

36. West Allis <--> Milwaukee

    No path planned or under construction at this time.

37. Waukesha <--> Milwaukee

    a. Access Wisconsin

38. Pewaukee <--> Milwaukee

    a. Access Wisconsin - via Waukesha

39. Mequon <--> Milwaukee

    No path planned or under construction at this time.

40. Oak Creek <--> Milwaukee

    a. Access Wisconsin

41. West Bend <--> Fond Du Lac

    a. Access Wisconsin

42. Beaver Dam <--> Fond Du Lac

    No path planned or under construction at this time.

43. Fox Lake <--> Waupun

    No path planned or under construction at this time.

44. Waupun <--> Fond Du Lac

    No path planned or under construction at this time.

45. Rippon <--> Fond Du Lac

    No path planned or under construction at this time.

46. Oshkosh <--> Neenah

    a. Access Wisconsin

47. Neenah <--> Appleton

    No path planned or under construction at this time.

48. Chilton <--> Appleton

    No path planned or under construction at this time.

49. Clintonville <--> Appleton

    a. Access Wisconsin

50. Wautoma <--> Waupaca

    No path planned or under construction at this time.

51. Waupaca <--> Appleton

    a. Access Wisconsin

52. Gillett <--> Green Bay

    No path planned or under construction at this time.

53. Marinette <--> Green Bay

    a. Access Wisconsin

54. Green Bay <--> Sturgeon Bay

    a. Access Wisconsin

55. Manitowoc <--> Cleveland

    a. Access Wisconsin (parts under construction)

56. Sheboygan <--> Cleveland

    a. Access Wisconsin

57. Watertown <--> Madison

    No path planned or under construction at this time.

58. Ft. Atkinson <--> Madison

The following timeline is offered for interconnection of all of the above-referenced sites:

FIRST HALF OF 1994

Milwaukee <--> Elkhorn via MRC Microwave
Milwaukee <--> Madison via MRC or State Patrol Microwave
Milwaukee <--> DePere via MRC or State Patrol Microwave
Milwaukee <--> Appleton via MRC Microwave

SECOND HALF OF 1994

Appleton <--> Green Bay via MRC Microwave
Madison <--> La Crosse via MRC or State Patrol Microwave
Milwaukee <--> Wausau via MCI Fiber
Madison <--> Wausau via MRC or State Patrol Microwave

FIRST HALF OF 1995

Chippewa Falls <--> WHWC-TV/FM via MRC Microwave
La Crosse <--> Eau Claire via MRC Fiber
Wausau <--> Appleton via MRC Microwave
Eau Claire <--> Wausau via MRC or State Patrol Microwave

SECOND HALF OF 1995

Milwaukee <--> Racine via MRC or MCI Fiber
Kenosha <--> Racine via State Patrol Microwave
Madison <--> Janesville via State Patrol Microwave
Madison <--> Portage via State Patrol Microwave

FIRST HALF OF 1996

Eau Claire <--> Hudson via MRC or State Patrol Microwave
Eau Claire <--> Rice Lake via State Patrol Microwave
Wausau <--> Rhinelander via State Patrol Microwave
Appleton <--> Cleveland via Access Wisconsin Fiber to be constructed

SECOND HALF OF 1996

New Richmond <--> Hudson via State Patrol Microwave
River Falls <--> Hudson via State Patrol Microwave
Superior <--> Hudson via MCI Fiber
Ashland <--> Superior via Access Wisconsin Fiber
Madison <--> Appleton via Access Wisconsin Fiber to be constructed

FIRST HALF OF 1997

Cumberland <--> Rice Lake via Access Wisconsin Fiber
Shell Lake <--> Rice Lake via Access Wisconsin Fiber
Chippewa Falls <--> Eau Claire via Access Wisconsin Fiber
Ladysmith <--> Eau Claire via Access Wisconsin Fiber
Menomonie <--> Eau Claire via State Patrol Microwave

SECOND HALF OF 1997

Black River Falls <--> La Crosse via State Patrol Microwave
Sparta <--> La Crosse via State Patrol Microwave
Tomah <--> La Crosse via State Patrol Microwave
Mauston <--> La Crosse via Access Wisconsin Fiber
Viroqua <--> La Crosse via Access Wisconsin Fiber

FIRST HALF OF 1998

Independence <--> La Crosse via MRC Microwave
Richland Center <--> Fennimore via Access Wisconsin Fiber
Platteville <--> Fennimore via Access Wisconsin Fiber
Park Falls <--> Phillips via MRC Microwave
Phillips <--> Wausau via MRC Microwave

SECOND HALF OF 1998

Minocqua <--> Rhinelander via State Patrol Microwave
Tomahawk <--> Rhinelander via Access Wisconsin Fiber
Spencer <--> Marshfield via MRC or State Patrol Microwave
Marshfield <--> Wausau via MRC or State Patrol Microwave

FIRST HALF OF 1999

Antigo <--> Wausau via Access Wisconsin Fiber
Medford <--> Wausau via Access Wisconsin Fiber
Wittenberg <--> Wausau via State Patrol Microwave
Stevens Point <--> Wausau via MRC Microwave
Wisconsin Rapids <--> Wausau via MRC Microwave

SECOND HALF OF 1999

Reedsburg <--> Portage via State Patrol Microwave
Baraboo <--> Portage via State Patrol Microwave
Adams <--> Portage via State Patrol Microwave
Monroe <--> Janesville via Access Wisconsin Fiber
Beloit <--> Janesville via Access Wisconsin Fiber

FIRST HALF OF 2000

Whitewater <--> Milton via Access Wisconsin Fiber to be constructed
Milton <--> Janesville via Access Wisconsin Fiber
Elkhorn <--> Milwaukee via Access Wisconsin Fiber to be constructed
West Allis <--> Milwaukee via Access Wisconsin Fiber to be constructed
Oak Creek <--> Milwaukee via Access Wisconsin Fiber

SECOND HALF OF 2000

Waukesha <--> Milwaukee via Access Wisconsin Fiber
Mequon <--> Milwaukee via Access Wisconsin Fiber
Pewaukee <--> Milwaukee via Access Wisconsin Fiber
West Bend <--> Fond Du Lac via Access Wisconsin Fiber
Beaver Dam <--> Fond Du Lac via Access Wisconsin Fiber to be constructed

FIRST HALF OF 2001

Fox Lake <--> Waupun Lac via Access Wisconsin Fiber to be constructed
Waupun <--> Fond Du Lac via Access Wisconsin Fiber to be constructed
Gillett <--> Green Bay via Access Wisconsin Fiber to be constructed
Marinette <--> Green Bay via Access Wisconsin Fiber
Manitowoc <--> Cleveland via Access Wisconsin Fiber

SECOND HALF OF 2001

Sheboygan <--> Cleveland via Access Wisconsin Fiber
Rippon <--> Fond Du Lac via Access Wisconsin Fiber to be constructed
Oshkosh <--> Appleton via Access Wisconsin Fiber
Neenah <--> Appleton via Access Wisconsin Fiber to be constructed
Wautoma <--> Waupaca via Access Wisconsin Fiber to be constructed
Waupaca <--> Appleton via Access Wisconsin Fiber

FIRST HALF OF 2002

Chilton <--> Appleton via Access Wisconsin Fiber to be constructed
Clintonville <--> Appleton via Access Wisconsin Fiber
Milwaukee <--> Madison via MCI Fiber
Milwaukee <--> DePere via Access Wisconsin Fiber to be constructed
Milwaukee <--> Appleton via MRC or MCI Fiber
Madison <--> La Crosse via MCI Fiber

SECOND HALF OF 2002

Madison <--> Wausau via MCI Fiber
Madison <--> Janesville via MCI Fiber
Reedsburg <--> Portage via Access Wisconsin Fiber
Baraboo <--> Portage via Access Wisconsin Fiber
Madison <--> Fennimore via Access Wisconsin Fiber to be constructed
Madison <--> Portage via Access Wisconsin Fiber to be constructed

FIRST HALF OF 2003

Eau Claire <--> Hudson via MRC Fiber
Milwaukee <--> Elkhorn via Access Wisconsin Fiber to be constructed
Madison <--> Watertown via Access Wisconsin Fiber to be constructed
Ft. Atkinson <--> Watertown via Access Wisconsin Fiber to be constructed

SECOND HALF OF 2003

Eau Claire <--> Rice Lake via Access Wisconsin Fiber to be constructed
Wausau <--> Rhinelander via Access Wisconsin Fiber to be constructed

Appleton <--> Green Bay via MRC or MCI Fiber
Chippewa Falls <--> WHWC-TV/FM via Access Wisconsin Fiber to be constructed

FIRST HALF OF 2004

Appleton <--> Fond Du Lac via Access Wisconsin Fiber to be constructed
Hudson <--> New Richmond via Access Wisconsin Fiber
Hudson <--> River Falls via Access Wisconsin Fiber
Chippewa Falls <--> Eau Claire via Access Wisconsin Fiber
Ladysmith <--> Eau Claire via Access Wisconsin Fiber

SECOND HALF OF 2004

Black River Falls <--> La Crosse via Access Wisconsin Fiber
Sparta <--> La Crosse via Access Wisconsin Fiber
Independence <--> La Crosse via Access Wisconsin Fiber
Menomonie <--> Eau Claire via Access Wisconsin Fiber
Adams <--> Portage via Access Wisconsin Fiber

FIRST HALF OF 2005

Tomah <--> La Crosse via Access Wisconsin Fiber
Park Falls <--> Phillips via Access Wisconsin Fiber
Phillips <--> Wausau via Access Wisconsin Fiber
Minocqua <--> Rhinelander via Access Wisconsin Fiber
Kenosha <--> Racine via Access Wisconsin Fiber to be constructed

SECOND HALF OF 2005

Spencer <--> Marshfield via Access Wisconsin Fiber
Marshfield <--> Wausau via Access Wisconsin Fiber
Wittenberg <--> Wausau via Access Wisconsin Fiber
Stevens Point <--> Wausau via Access Wisconsin Fiber
Wisconsin Rapids <--> Wausau via Access Wisconsin Fiber

FIBER$.XLS: Unallocated And Allocated Fiber Costs

Network Link	Miles	Cost/Mi	Circuits	Max Strands	Channels Per Strand	Unallocated Cost	# Strands Needed	# Strands Protection	Allocation Factor	Allocated Cost
Appleton-Madison	98	$14,520	12	24	12	$1,422,960	2	2	0.1666667	$237,160
Appleton-Milwaukee	85	$14,520	12	24	12	$1,234,200	2	2	0.1666667	$205,700
Eau Claire-Wausau	91	$14,520	12	24	12	$1,321,320	2	2	0.1666667	$220,220
La Crosse-Eau Claire	68	$14,520	12	24	12	$987,360	2	2	0.1666667	$164,560
Madison-La Crosse	111	$14,520	12	24	12	$1,611,720	2	2	0.1666667	$268,620
Madison-Milwaukee	65	$14,520	12	24	12	$943,800	2	2	0.1666667	$157,300
Wausau-Appleton	75	$14,520	12	24	12	$1,089,000	2	2	0.1666667	$181,500
Appleton-Green Bay	24	$14,520	6	24	12	$348,480	2	2	0.0833333	$29,040
Appleton-Oshkosh	20	$14,520	6	24	12	$290,400	2	2	0.0833333	$24,200
Appleton-Sheboygan	46	$14,520	6	24	12	$667,920	2	2	0.0833333	$55,660
Eau Claire-Shell Lake	68	$14,520	6	24	12	$987,360	2	2	0.0833333	$82,280
Madison-Fennemore	65	$14,520	6	24	12	$943,800	2	2	0.0833333	$78,650
Madison-Janesville	33	$14,520	6	24	12	$479,160	2	2	0.0833333	$39,930
Milwaukee-Kenosha	33	$14,520	6	24	12	$479,160	2	2	0.0833333	$39,930
Oshkosh-Fond du Lac	16	$14,520	6	24	12	$232,320	2	2	0.0833333	$19,360
Wausau-Rhinelander	49	$14,520	6	24	12	$711,480	2	2	0.0833333	$59,290
Wausau-Wisconsin Rapids	39	$14,520	6	24	12	$566,280	2	2	0.0833333	$47,190
Appleton-Chilton	20	$14,520	3	24	12	$290,400	2	2	0.0416667	$12,100
Appleton-Clintonville	33	$14,520	3	24	12	$479,160	2	2	0.0416667	$19,965
Appleton-Neenah	6	$14,520	3	24	12	$87,120	2	2	0.0416667	$3,630
Appleton-Wautoma	46	$14,520	3	24	12	$667,920	2	2	0.0416667	$27,830
Eau Claire-Chippewa Falls	13	$14,520	3	24	12	$188,760	2	2	0.0416667	$7,865
Eau Claire-Ladysmith	49	$14,520	3	24	12	$711,480	2	2	0.0416667	$29,645
Eau Claire-Menomonie	20	$14,520	3	24	12	$290,400	2	2	0.0416667	$12,100
Eau Claire-River Falls	55	$14,520	3	24	12	$798,600	2	2	0.0416667	$33,275
Fennemore-Platteville	16	$14,520	3	24	12	$232,320	2	2	0.0416667	$9,680
Fennemore-Richland Center	29	$14,520	3	24	12	$421,080	2	2	0.0416667	$17,545
Fond du Lac-Beaver Dam	29	$14,520	3	24	12	$421,080	2	2	0.0416667	$17,545
Fond du Lac-Fox Lake	29	$14,520	3	24	12	$421,080	2	2	0.0416667	$17,545
Fond du Lac-Ripon	20	$14,520	3	24	12	$290,400	2	2	0.0416667	$12,100
Fond du Lac-Waupun	20	$14,520	3	24	12	$290,400	2	2	0.0416667	$12,100
Fond du Lac-West Bend	29	$14,520	3	24	12	$421,080	2	2	0.0416667	$17,545
Green Bay-Gillett	33	$14,520	3	24	12	$479,160	2	2	0.0416667	$19,965
Green Bay-Marinette	42	$14,520	3	24	12	$609,840	2	2	0.0416667	$25,410

FIBER$.XLS: Unallocated And Allocated Fiber Costs

Network Link	Miles	Cost/Mi	Circuits	Max Strands	Channels Per Strand	Unallocated Cost	# Strands Needed	# Strands Protection	Allocation Factor	Allocated Cost
Green Bay-Sturgeon Bay	39	$14,520	3	24	12	$566,280	2	2	0.0416667	$23,595
Janesv ille-Beloit	15	$14,520	3	24	12	$217,800	2	2	0.0416667	$9,075
Janesv ille-Milton	15	$14,520	3	24	12	$217,800	2	2	0.0416667	$9,075
Janesville-Monroe	33	$14,520	3	24	12	$479,160	2	2	0.0416667	$19,965
Kenosha-Elkhorn	36	$14,520	3	24	12	$522,720	2	2	0.0416667	$21,780
Kenosha-Racine	10	$14,520	3	24	12	$145,200	2	2	0.0416667	$6,050
La Crosse-Independence	39	$14,520	3	24	12	$566,280	2	2	0.0416667	$23,595
La Crosse-Mauston	60	$14,520	3	24	12	$871,200	2	2	0.0416667	$36,300
La Crosse-Tomah	36	$14,520	3	24	12	$522,720	2	2	0.0416667	$21,780
La Crosse-Viroqua	29	$14,520	3	24	12	$421,080	2	2	0.0416667	$17,545
Madison-Fort Atkinson	29	$14,520	3	24	12	$421,080	2	2	0.0416667	$17,545
Madison-Portage	33	$14,520	3	24	12	$479,160	2	2	0.0416667	$19,965
Madison-Reedsburg	46	$14,520	3	24	12	$667,920	2	2	0.0416667	$27,830
Madison-Watertown	36	$14,520	3	24	12	$522,720	2	2	0.0416667	$21,780
Milton-Whitewater	10	$14,520	3	24	12	$145,200	2	2	0.0416667	$6,050
Milwaukee-Mequon	16	$14,520	3	24	12	$232,320	2	2	0.0416667	$9,680
Milwaukee-Oak Creek	13	$14,520	3	24	12	$188,760	2	2	0.0416667	$7,865
Milwaukee-Pewaukee	16	$14,520	3	24	12	$232,320	2	2	0.0416667	$9,680
Milwaukee-Waukesha	10	$14,520	3	24	12	$145,200	2	2	0.0416667	$6,050
Milwaukee-West Allis	8	$14,520	3	24	12	$116,160	2	2	0.0416667	$4,840
Rhinelander-Minocqua	23	$14,520	3	24	12	$333,960	2	2	0.0416667	$13,915
Rhinelander-Tomahawk	20	$14,520	3	24	12	$290,400	2	2	0.0416667	$12,100
Sheboygan-Cleveland	24	$14,520	3	24	12	$348,480	2	2	0.0416667	$14,520
Sheboygan-Manitowoc	24	$14,520	3	24	12	$348,480	2	2	0.0416667	$14,520
Shell Lake-Ashland	75	$14,520	3	24	12	$1,089,000	2	2	0.0416667	$45,375
Shell Lake-Cumberland	16	$14,520	3	24	12	$232,320	2	2	0.0416667	$9,680
Shell Lake-Rice Lake	20	$14,520	3	24	12	$290,400	2	2	0.0416667	$12,100
Shell Lake-Richland	52	$14,520	3	24	12	$755,040	2	2	0.0416667	$31,460
Shell Lake-Superior	65	$14,520	3	24	12	$943,800	2	2	0.0416667	$39,325
Wausau-Antigo	26	$14,520	3	24	12	$377,520	2	2	0.0416667	$15,730
Wausau-Medford	39	$14,520	3	24	12	$566,280	2	2	0.0416667	$23,595
Wausau-Phillips	62	$14,520	3	24	12	$900,240	2	2	0.0416667	$37,510
Wausau-Wittenberg	26	$14,520	3	24	12	$377,520	2	2	0.0416667	$15,730
Wisconsin Rapids-Adams Frdsh	29	$14,520	3	24	12	$421,080	2	2	0.0416667	$17,545
Wisconsin Rapids-Marshfield	26	$14,520	3	24	12	$377,520	2	2	0.0416667	$15,730

FIBER$.XLS: Unallocated And Allocated Fiber Costs

Network Link	Miles	Cost/Mi	Circuits	Max Strands	Channels Per Strand	Unallocated Cost	# Strands Needed	# Strands Protection	Allocation Factor	Allocated Cost
Wisconsin Rapids-Stevens Point	13	$14,520	3	24	12	$188,760	2	2	0.0416667	$7,865
						$36,938,880			Total Cost:	$2,853,180

City	TV Sites	VTAE	CESA	ITFS Site	2 Year	4 Year	Cty. Seat	Ind. Coll	Library System	Prison	Freq
La Crosse	X	X	X			X	X	X	X		6
Madison	X	X				X	X	X	X		5
Janesville		X			X		X		X		4
Green Bay	X	X	X			X	X	X	X	X	7
Eau Claire		X				X	X		X		4
Superior	X	X		X		X	X				4
Ashland		X	X				X	X	X		5
Wausau	X	X			X		X		X		4
Kenosha		X				X	X		X		5
Racine		X					X		X	X	4
Waukesha/Pewaukee		X			X				X		3
Milwaukee		X	X			X	X	9	X		14
Portage		X	X				X			X	4
Baraboo					X		X				2
Fennimore		X	X						X		3
Richland Ctr					X		X				2
Wis. Rapids		X					X				2
Marshfield		X			X						2
Stevens Point		X				X	X				3
Fond du Lac		X			X		X	X	X	X	6
Manitowoc					X		X	X	X		4
Oshkosh		X	X			X	X			X	5
Appleton/Nee/Men	X	X			X		X	X	X		5
Sturgeon Bay		X					X				2
Marinette		X			X		X				3
Sheboygan					X		X	X	X		4
West Bend		X			X		X				3
Antigo		X					X				2
Medford		X					X				2
Phillips		X					X				2

APPENDIX N-17

City	TV Sites	VTAE	CESA	ITFS Site	2 Year	4 Year	Cty. Seat	Ind. Coll	Library System	Prison	Freq
Rhinelander		X					X				2
Chippewa Falls		X	X				X				3
Rice Lake		X			X						2
Beloit								X			1
Ladysmith								X			1
Ripon								X			1
Shell Lake		X					X				2
Cleveland		X									
River Falls						X					1
Platteville						X					1
Whitewater						X					1
Menomonie	X					X	X				2
Milton			X								1
Gillett			X								1
Tomahawk			X								1
Cumberland			X								1
Waupun										X	1
Fox Lake										X	1
Weyerhaeuser				X							1
Park Falls	X										
Delafield	X										

City	TV Sites	VTAE	CESA	ITFS Site	2 Year	4 Year	Cty. Seat	Ind. Coll	Library System	Prison	Freq
WITC(Shell Lake)		X					X	X	X		6
N. Richmond		X									
Rice Lake		X									
Ashland		X					X				
Superior		X					X				
Chippewa Val(EC)		X					X				
Chippewa Falls		X					X				
River Falls		X									
WWTC (LaCrosse)		X					X				
Independence		X									
Tomah		X									
Mauston		X					X				
Viroqua		X					X				
MATC (Madison)		X					X				
Reedsburg		X									
Portage		X					X				
Watertown		X									
Ft. Atkinson		X									
Blackhawk (Janesville)		X					X				
Monroe		X					X				
Beloit		X									
Gateway (Kenosha)		X					X				
Elkhorn		X					X				
Racine		X					X				
MATC (Milwaukee)		X					X				
Mequon		X									
West Allis		X									
Oak Creek		X									

City	TV Sites	VTAE	CESA	ITFS Site	2 Year	4 Year	Cty. Seat	Ind. Coll	Library System	Prison	Freq
Wauk Co. (Pewaukee		X									
Moraine Park (FondduLac)		X					X				
Beaver Dam		X									
West Bend		X					X				
FVTC (Appleton)		X					X				
Clintonville		X									
Wautoma		X					X				
Oshkosh		X					X				
Neenah		X									
Chilton		X					X				
LakeshoreTC (Cleveland)		X									
NortheastWis (Green Bay)		X					X				
Sturgeon Bay		X					X				
Marinette		X					X				
Midstate (WisRapids)		X					X				
Stevens Point		X					X				
Adams-Friendship		X					X(Friendship)				
Marshfield		X									
Northcentral (Wausau)		X					X				
Wittenberg		X									
Antigo		X					X				
Medford		X					X				
Phillips		X					X				
Nicolet (Rhinelander)		X					X				
Minocqua		X									
Southwest (Fennimore)		X									

DISTANCE AND BEARING

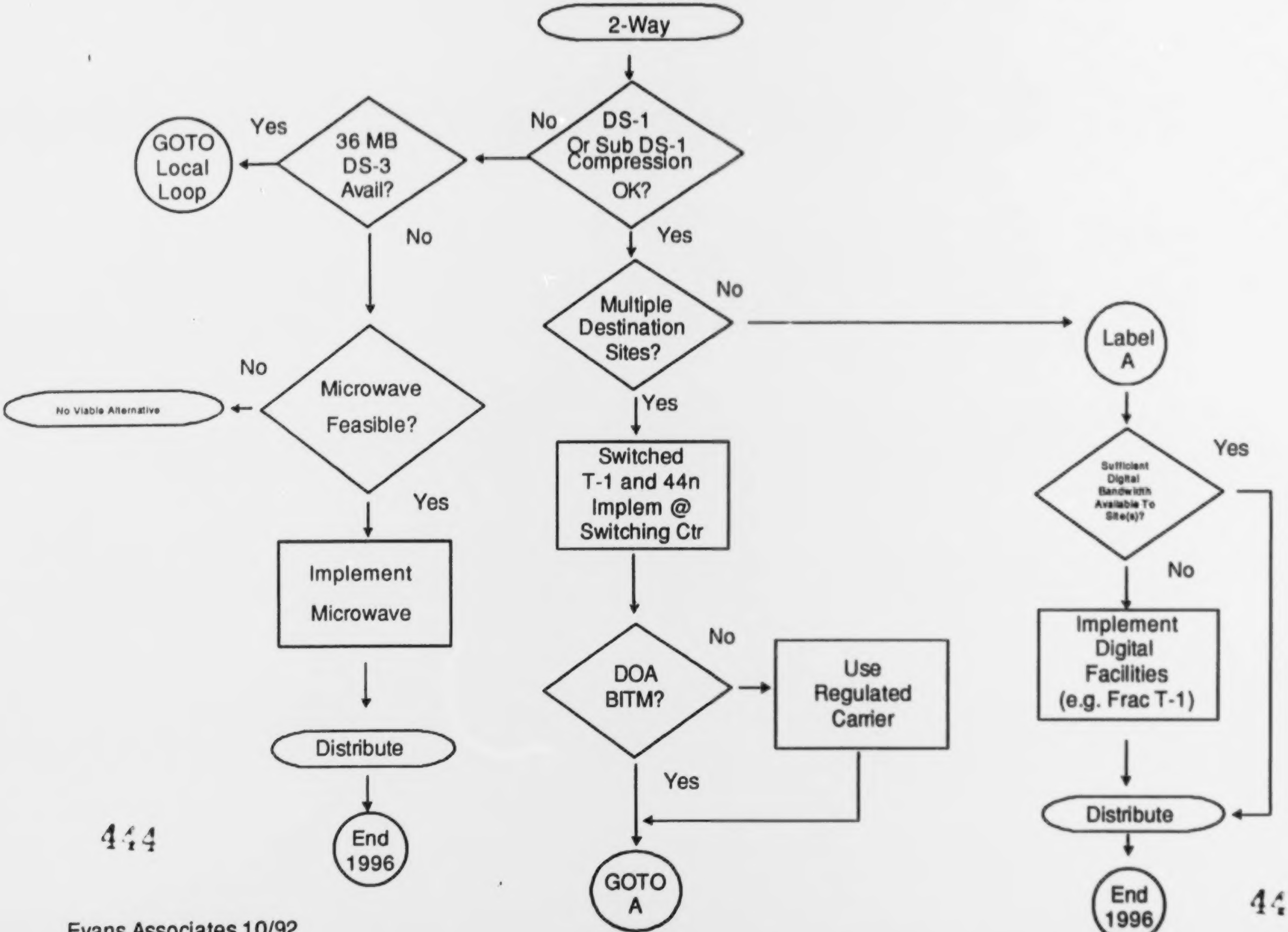
Ashland <--> Superior	58.63 miles/94.36 km	280.28°
Superior <--> Hudson	125.5 miles/202.04 km	194.62°
New Richmond <--> Hudson	14.67 miles/23.61 km	225.76°
River Falls <--> Hudson	10.03 miles/16.15 km	322.32°
Hudson <--> Eau Claire	62.43 miles/100.48 km	99.86°
Menomonie <--> Eau Claire	21.21 miles/34.13 km	101.92°
Chippewa Falls <--> Eau Claire	9.91 miles/15.95 km	30.78°
Ladysmith <--> Eau Claire	47.53 miles/76.50 km	197.92°
Eau Claire <--> Rice Lake	49.11 miles/79.03 km	166.04°
Cumberland <--> Rice Lake	13.93 miles/22.41 km	99.90°
Shell Lake <--> Rice Lake	18.39 miles/29.59 km	150.21°
Eau Claire <--> Wausau	91.37 miles/147.04 km	82.98°
Medford <--> Wausau	36.02 miles/57.97 km	110.54°
Park Falls <--> Phillips	17.32 miles/27.87 km	171.77°
Phillips <--> Wausau	62.48 miles/100.55 km	143.59°
Spencer <--> Marshfield	31.63 miles/50.90 km	248.79°
Marshfield <--> Wausau	33.15 miles/53.35 km	51.87°
Wisconsin Rapids <--> Wausau	40.62 miles/65.38 km	12.75°
Stevens Point <--> Wausau	30.69 miles/49.39 km	353.90°
Wittenberg <--> Wausau	25.00 miles/40.24 km	292.26°
Antigo <--> Wausau	26.86 miles/43.22 km	242.31°
Wausau <--> Rhinelander	48.09 miles/77.39 km	12.87°

Tomahawk <--> Rhinelander	18.91 miles/30.43 km	52.37°
Minocqua <--> Rhinelander	21.33 miles /34.33 km	138.75°
Wausau <--> Appleton	77.00 miles/123.92 km	309.23°
Clintonville <--> Appleton	30.05 miles/48.35 km	145.76°
Chilton <--> Appleton	13.74 miles/22.11 km	290.02°
Oshkosh <--> Neenah	12.92 miles/20.80 km	21.35°
Neenah <--> Appleton	4.78 miles/7.70 km	18.14°
Wautoma <--> Waupaca	22.07 miles/35.52 km	21.35°
Appleton <--> Green Bay	26.81 miles/43.15 km	49.42°
Gillett <--> Green Bay	29.90 miles/48.12 km	150.62°
Marinette <--> Green Bay	44.30 miles/71.30 km	204.30°
Sturgeon Bay <--> Green Bay	38.11 miles/61.33 km	234.12°
Appleton <--> Cleveland	41.37 miles/66.59 km	126.02°
Manitowoc <--> Cleveland	13.10 miles/21.08 km	199.10°
Sheboygan <--> Cleveland	10.18 miles/16.39 km	0.16°
Appleton <--> Fond Du Lac	33.31 miles/53.61 km	182.43°
Rippon <--> Fond Du Lac	19.93 miles/32.08 km	102.55°
Fox Lake <--> Waupun	10.22 miles/16.44 km	61.15°
Waupun <--> Fond Du Lac	17.34 miles/27.90 km	54.14°
Beaver Dam <--> Fond Du Lac	31.14 miles/50.11 km	44.61°
West Bend <--> Fond Du Lac	28.47 miles/45.82 km	331.95°
Appleton <--> Milwaukee	88.24 miles/142.00 km	163.49°
Mequon <--> Milwaukee	12.58 miles/20.25 km	173.15°
Pewaukee <--> Milwaukee	17.17 miles/27.64 km	99.92°

Waukesha <--> Milwaukee	16.42 miles/26.43 km	83.85°
West Allis <--> Milwaukee	5.72 miles/9.20 km	73.23°
Oak Creek <--> Milwaukee	12.70 miles/20.44 km	346.33°
Elkhorn <--> Milwaukee	48.97 miles/78.80 km	41.04°
Milwaukee <--> Racine	22.29 miles/35.86 km	165.04°
Racine <--> Kenosha	9.85 miles/15.85 km	186.93°
Milwaukee <--> Wausau	158.08 miles/254.41 km	327.72°
Milwaukee <--> Madison	74.75 miles/120.30 km	272.18°
Madison <--> Wausau	131.16 miles/211.08 km	354.72°
Watertown <--> Madison	34.93 miles/56.21 km	255.52°
Ft. Atkinson <--> Madison	29.59 miles/47.62 km	289.27°
Madison <--> Appleton	95.63 miles/153.90 km	30.24°
Madison <--> Portage	32.88 miles/52.91 km	354.17°
Baraboo <--> Portage	15.74 miles/25.32 km	114.56°
Reedsburg <--> Portage	29.48 miles/47.45 km	111.83°
Adams <--> Portage	33.77 miles/54.35 km	147.98°
Madison <--> Janesville	32.82 miles/52.82 km	144.71°
Whitewater <--> Milton	11.34 miles/18.24 km	248.88°
Milton <--> Janesville	7.49 miles/12.05 km	211.52°
Beloit <--> Janesville	11.98 miles/19.28 km	2.85°
Monroe <--> Janesville	31.93 miles/51.39 km	79.61°
Madison <--> Fennimore	64.06 miles/103.09 km	265.10°
Platteville <--> Fennimore	19.25 miles/30.97 km	331.89°
Richland Center <--> Fennimore	28.12 miles/45.26 km	208.57°

Madison <--> La Crosse	106.38 miles/171.21 km	299.50°
Viroqua <--> La Crosse	25.26 miles/40.65 km	314.36 °
Tomah <--> Sparta	15.67 miles/25.22 km	258.23°
Sparta <--> La Crosse	23.38 miles/37.63 km	248.78°
Black River Falls <--> La Crosse	38.86 miles/63.53 km	211.22°
Independence <--> La Crosse	39.54 miles/63.64 km	167.50°
La Crosse <--> Eau Claire	70.14 miles/112.88 km	350.16°

WECB Migration Study: 2-Way Video Implementation For Distance Ed Page 1



2-Way

DS-1 Or Sub DS-1 Compression OK?

No

36 MB DS-3 Avail?

Yes

GOTO Local Loop

No

Microwave Feasible?

No

No Viable Alternative

Yes

Implement Microwave

Distribute

End 1996

Yes

Multiple Destination Sites?

No

Label A

Sufficient Digital Bandwidth Available To Site(s)?

Yes

No

Implement Digital Facilities (e.g. Frac T-1)

Distribute

End 1996

Yes

Switched T-1 and 44n Implem @ Switching Ctr

DOA BITM?

No

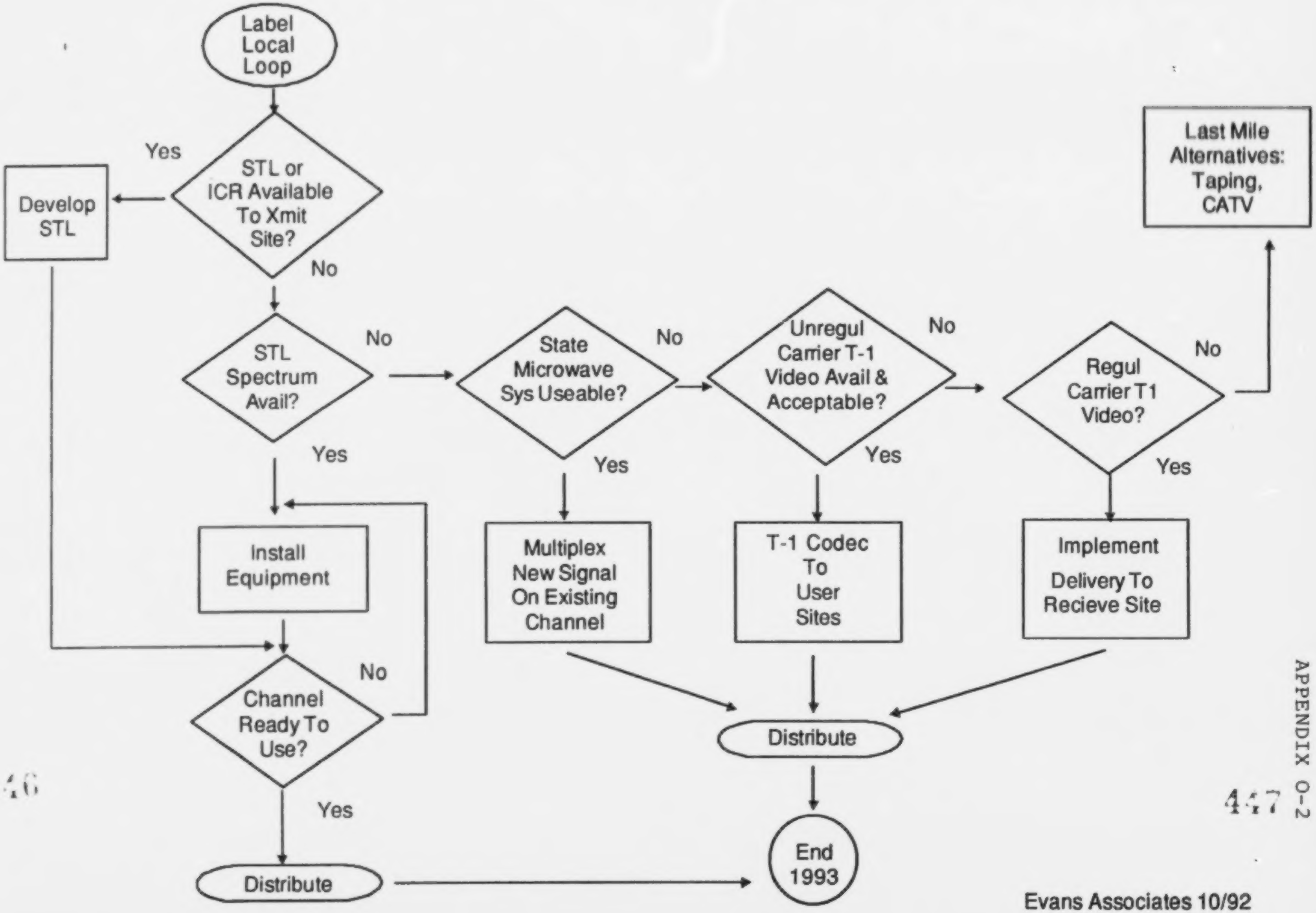
Use Regulated Carrier

Yes

GOTO A

Evans Associates 10/92

WECB Migration Study: 2-Way Video Implementation For Distance Ed Page 2



Label Local Loop

STL or ICR Available To Xmit Site?

Yes

Develop STL

No

STL Spectrum Avail?

No

State Microwave Sys Useable?

No

Unregul Carrier T-1 Video Avail & Acceptable?

No

Regul Carrier T1 Video?

No

Last Mile Alternatives: Taping, CATV

Yes

Install Equipment

Channel Ready To Use?

No

Yes

Distribute

Yes

Multiplex New Signal On Existing Channel

Yes

T-1 Codec To User Sites

Yes

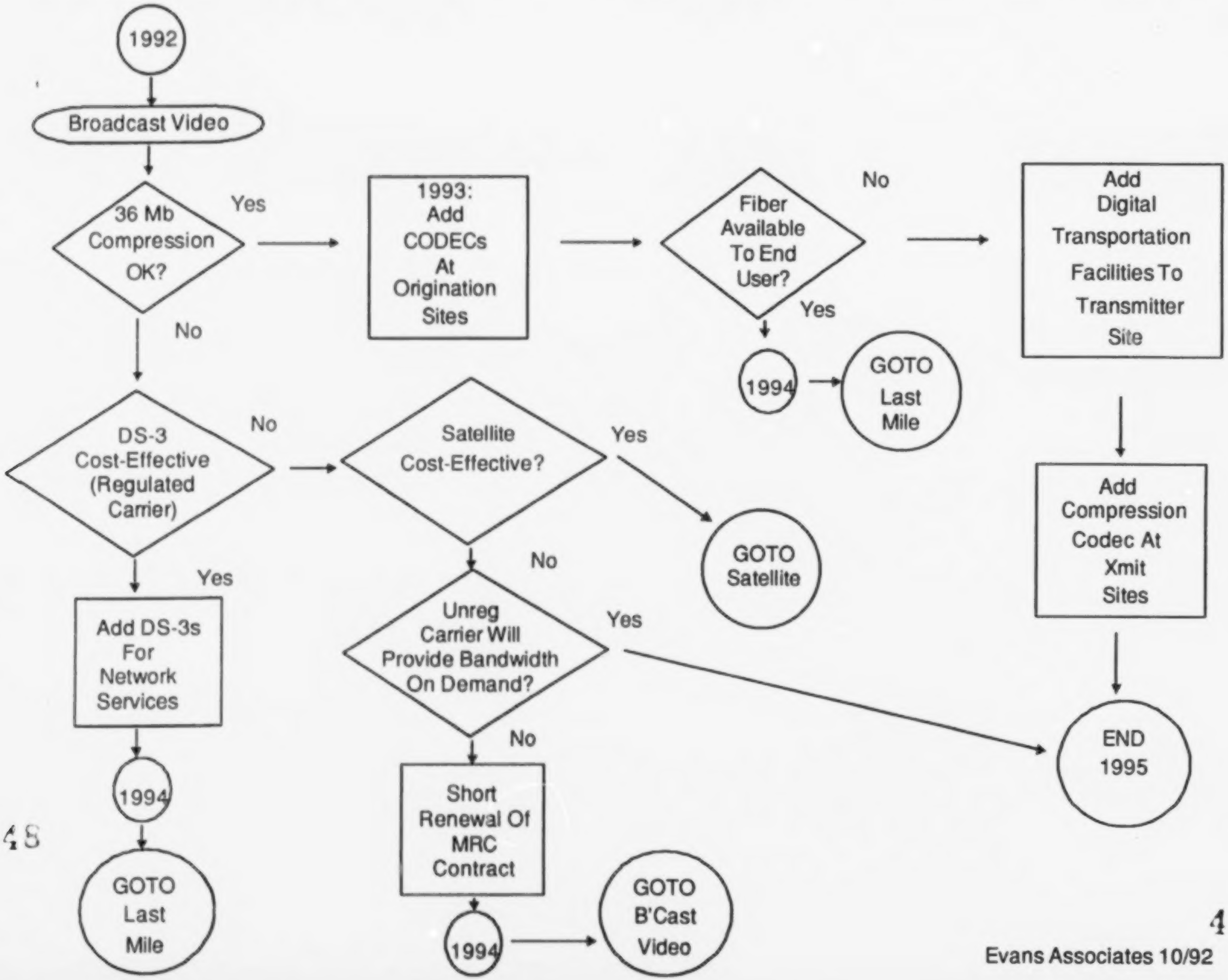
Implement Delivery To Recieve Site

Distribute

End 1993

Evans Associates 10/92

WECB Migration Study: Broadcast Video Network Implementation Page 1



1992

Broadcast Video

36 Mb Compression OK?

Yes

1993: Add CODECs At Origination Sites

Fiber Available To End User?

No

Add Digital Transportation Facilities To Transmitter Site

Yes

1994

GOTO Last Mile

Add Compression Codec At Xmit Sites

END 1995

No

DS-3 Cost-Effective (Regulated Carrier)

No

Satellite Cost-Effective?

Yes

GOTO Satellite

Yes

Add DS-3s For Network Services

1994

GOTO Last Mile

No

Unreg Carrier Will Provide Bandwidth On Demand?

Yes

No

Short Renewal Of MRC Contract

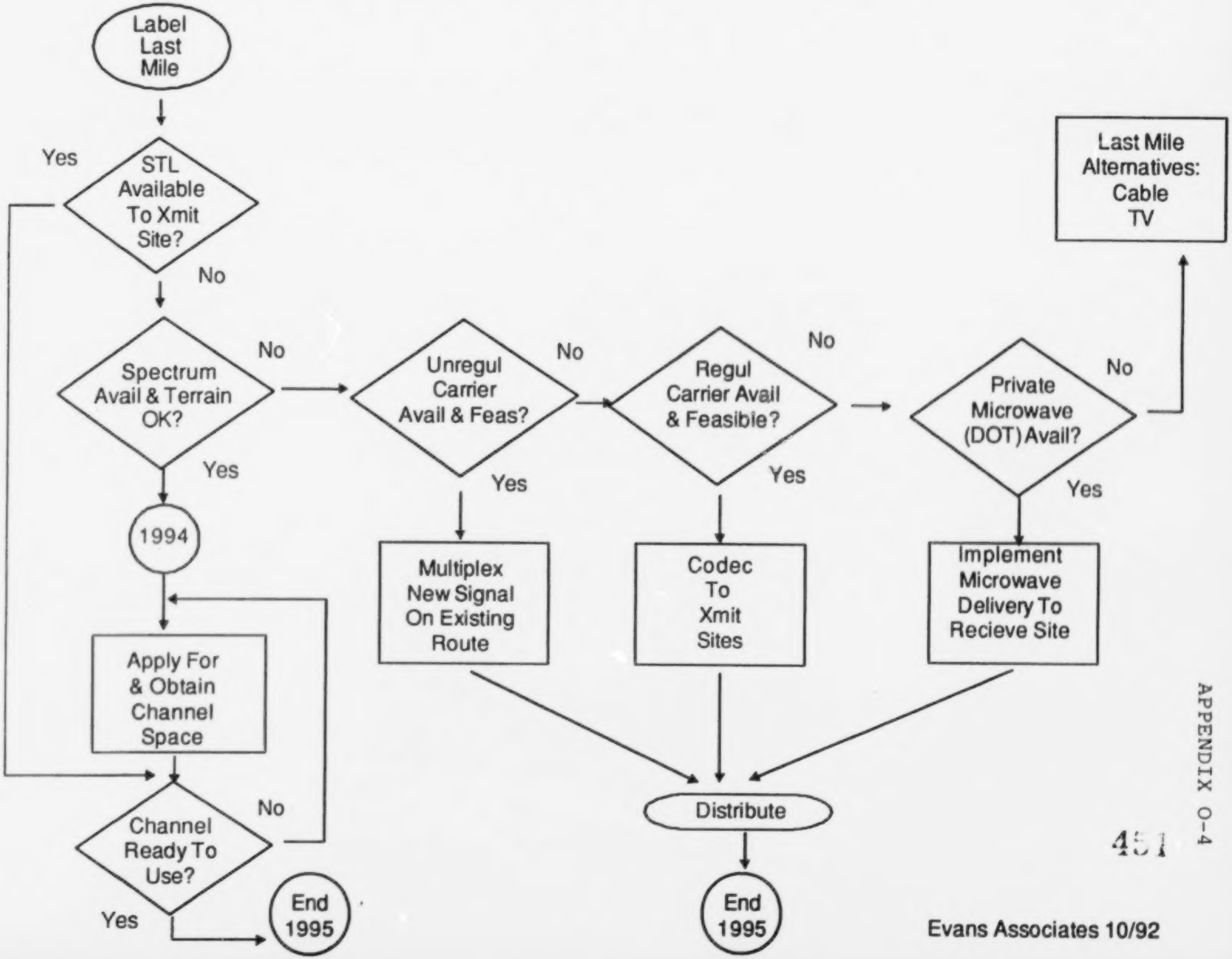
1994

GOTO B'Cast Video

APPENDIX O-3

Evans Associates 10/92

WECB Migration Study: Broadcast Video Network Implementation Page 2



Label Last Mile

STL Available To Xmit Site?

Yes

No

Spectrum Avail & Terrain OK?

No

Yes

1994

Apply For & Obtain Channel Space

Channel Ready To Use?

No

Yes

End 1995

Unregul Carrier Avail & Feas?

No

Yes

Multiplex New Signal On Existing Route

Regul Carrier Avail & Feasible?

No

Yes

Codec To Xmit Sites

Private Microwave (DOT) Avail?

No

Yes

Implement Microwave Delivery To Recieve Site

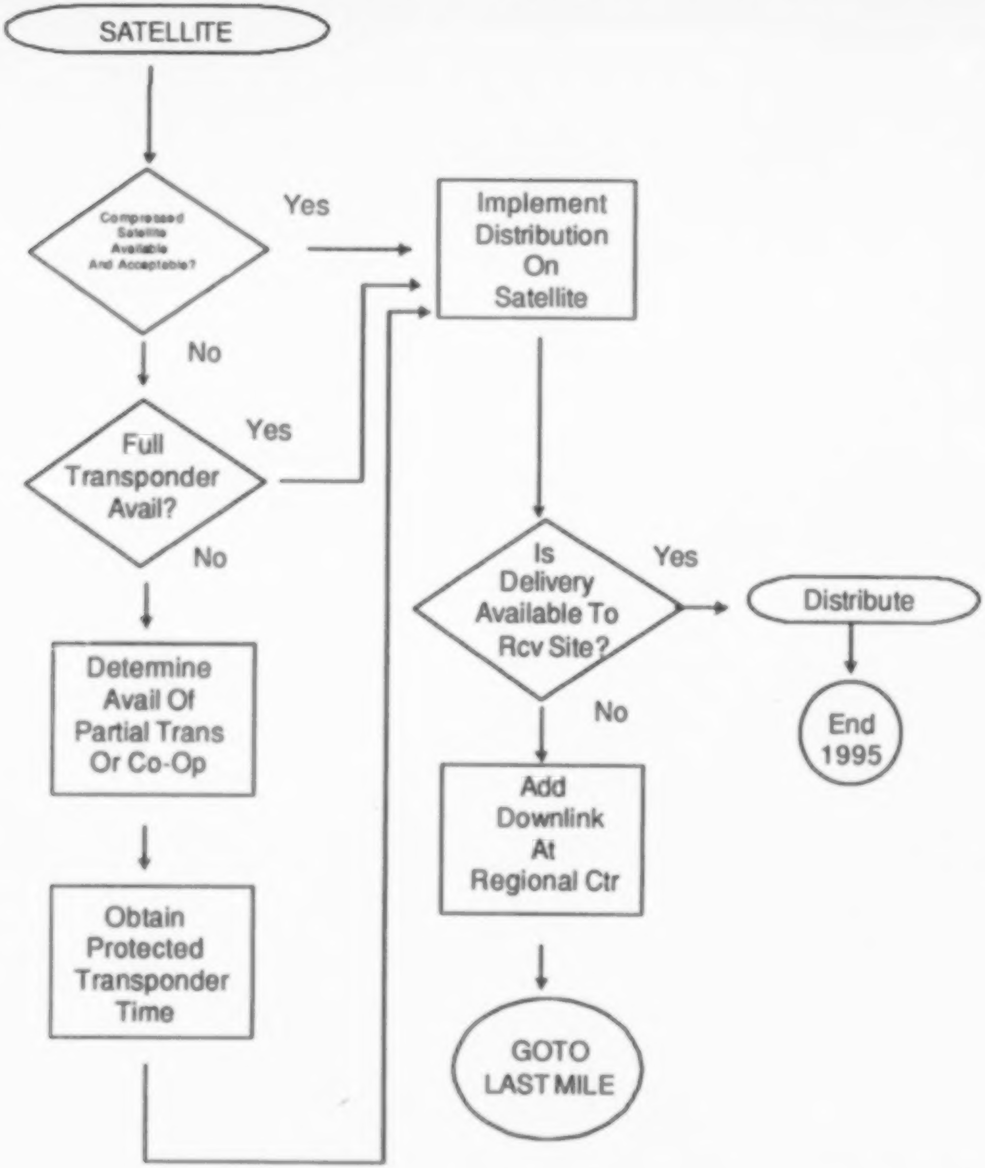
Last Mile Alternatives: Cable TV

Distribute

End 1995

Evans Associates 10/92

WECB Migration Study: Broadcast Video Network Implementation Page 3



SATELLITE

Compressed Satellite Available And Acceptable?

Yes

Implement Distribution On Satellite

No

Full Transponder Avail?

Yes

No

Determine Avail Of Partial Trans Or Co-Op

Obtain Protected Transponder Time

Is Delivery Available To Rcv Site?

Yes

Distribute

End 1995

No

Add Downlink At Regional Ctr

GOTO LAST MILE

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WECB Interconnect Configuration Options: Continue Present MRC Contract

									Lease		
Vendor	Product	Type	Mode	Bandwidth	Route	Purchase	Term	Inst Access	Access/Mo	Operate/Mo	TOTAL
Route Information											
MRC	BCB To All 7 TV Locs	Microwave	Analog	45 MB+128KB			3	$0.00	$0.00	$23,395.00	
MRC	BCB To All 9 FM Stations	Microwave	Analog	3*128KB+1*56KB			3	$0.00	$0.00	$13,227.00	
	Total Recurring Route Charges (mo)								$0	$36,622	$36,622
	Total Non-Recurring Route Charges					$0		$0			$0
Equipment Information											
	Total Recurring Equipment Charges (mo)								$0	$0	$0
	Total Non-Recurring Equipment Charges					$0		$0			$0
Other Information											
	Consulting Services										
	Maintenance Contracts										
	Total Recurring Other Charges (mo)								$0	$0	$0
	Total Non-Recurring Other Charges					$0		$0			$0
	Grand Total Recurring Charges (mo)								***$0***	***$36,622***	***$36,622***
	Grand Total Non-Recurring Charges					***$0***		***$0***			***$0***

WECB Interconnect Configuration Options: MRC Pricing w/ Video Audio Add-Ons

Vendor	Product	Type	Mode	Bandwidth	Route	Purchase	Term	Inst Access	Lease Access/Mo	Operate/Mo	TOTAL
Route Information											
MRC	ECB To All 7 TV Locs	Microwave	Analog	45 MB+3*128KB			3	$0.00	$0.00	$29,905.00	
MRC	ECB To 9 FM Sta+WHAD Music	Microwave	Analog	3*128KB+1*56KB			3	$0.00	$0.00	$13,842.00	
	Total Recurring Route Charges (mo)								**$0**	**$43,747**	**$43,747**
	Total Non-Recurring Route Charges					**$0**		**$0**			**$0**
Equipment Information											
	Total Recurring Equipment Charges (mo)								**$0**	**$0**	**$0**
	Total Non-Recurring Equipment Charges					**$0**		**$0**			**$0**
Other Information											
	Consulting Services										
	Maintenance Contracts										
	Total Recurring Other Charges (mo)								**$0**	**$0**	**$0**
	Total Non-Recurring Other Charges					**$0**		**$0**			**$0**
	Grand Total Recurring Charges (mo)								***$0***	***$43,747***	***$43,747***
	Grand Total Non-Recurring Charges					***$0***		***$0***			***$0***

WECB Interconnect Configuration Options: MCI Fiber

								Lease			
Vendor	Product	Type	Mode	Bandwidth	Route	Purchase	Term	Inst Access	Access/Mo	Operate/Mo	TOTAL
Route Information											
MCI	Madison	Fiber	Digital	DS-3			3	$1,590.00	$6,125.00	$0.00	
MCI	Milwaukee	Fiber	Digital	DS-3			3	$1,590.00	$5,110.00	$17,613.00	
MCI	Green Bay	Fiber	Digital	DS-3			3	$1,590.00	$6,455.00	$22,765.00	
MCI	De Pere	Fiber	Digital	DS-3			3	$1,590.00	$6,455.00	$22,765.00	
MCI	Wausau	Fiber	Digital	DS-3			3	$6,504.70	$7,010.00	$23,665.00	
MCI	Colfax	Fiber	Digital	DS-3			3	$1,590.00	$5,110.00	$26,185.00	
MCI	La Crescent	Fiber	Digital	DS-3			3	$1,253.50	$5,185.35	$21,685.00	
MCI	Park Falls	Fiber	Digital	DS-3			3	$1,590.00	$21,140.00	$30,223.00	
MCI	Madison	Fiber	Digital	T-1			3	$1,338.00	$781.00	$0.00	
MCI	Milwaukee	Fiber	Digital	T-1	76 Channel Miles Frm Madison		3	$1,338.00	$553.00	$2,520.68	
MCI	Green Bay	Fiber	Digital	T-1	121 Channel Miles Frm Madison		3	$1,338.00	$719.00	$2,801.40	
MCI	De Pere	Fiber	Digital	T-1	121 Channel Miles Frm Madison		3	$1,338.00	$719.00	$2,801.40	
MCI	Wausau	Fiber	Digital	T-1	131 Channel Miles Frm Madison		3	$778.00	$670.00	$2,855.40	
MCI	Colfax	Fiber	Digital	T-1	159 Channel Miles Frm Madison		3	$1,338.00	$553.00	$3,006.60	
MCI	La Crescent	Fiber	Digital	T-1	109 Channel Miles Frm Madison		3	$1,790.00	$1,527.00	$2,736.60	
MCI	Park Falls	Fiber	Digital	T-1	204 Channel Miles Frm Madison		3	$1,338.00	$3,183.00	$3,249.60	
	Total Recurring Route Charges (mo)								$71,295	$184,873	$256,168
	Total Non-Recurring Route Charges					$0		$27,894			$27,894
Equipment Information											
	Total Recurring Equipment Charges (mo)								$0	$0	$0
	Total Non-Recurring Equipment Charges					$0		$0			$0
Other Information											
	Consulting Services										
	Maintenance Contracts										

Appendix P-3

WECB Interconnect Configuration Options: MCI Fiber

								Lease			
Vendor	**Product**	**Type**	**Mode**	**Bandwidth**	**Route**	**Purchase**	**Term**	**Inst Access**	**Access/Mo**	**Operate/Mo**	**TOTAL**
	Total Recurring Other Charges (mo)								$0	$0	$0
	Total Non-Recurring Other Charges					$0		$0			$0
	Grand Total Recurring Charges (mo)								***$71,295***	***$184,873***	***$256,168***
	Grand Total Non-Recurring Charges					***$0***		***$27,894***			***$27,894***

OVERLAY.XLS: WECB Interconnect Configuration Options

Vendor	Product	Type	Mode	Bandwidth	Route	Purchase	Term	Lease			TOTAL
								Inst Access	Access/Mo	Operate/Mo	
Route Information											
	Fiber Costs (allocated)				(unallocated: $36,938,880)	$2,853,180					
	Total Recurring Route Charges (mo)								$0	$0	$0
	Total Non-Recurring Route Charges					$2,853,180		$0			$2,853,180
Equipment Information											
GVG	Major Node Switching Equip	Fiber	Digital	16 DS-3s	Eau Claire	$63,478					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	12 DS-3s	Eau Claire (2 units)	$85,680					
GVG	Additional 8-port cards (4)	Fiber	Digital		Eau Claire (4 cards)	$14,312					
GVG	Major Node Switching Equip	Fiber	Digital	16 DS-3s	La Crosse	$63,478					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	12 DS-3s	La Crosse (2 units)	$85,680					
GVG	Additional 8-port cards (3)	Fiber	Digital		La Crosse (3 cards)	$10,734					
GVG	Major Node Switching Equip	Fiber	Digital	16 DS-3s	Madison	$63,478					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	12 DS-3s	Madison (3 units)	$128,520					
GVG	Additional 8-port cards (5)	Fiber	Digital		Madison (5 cards)	$17,890					
GVG	Major Node Switching Equip	Fiber	Digital	16 DS-3s	Milwaukee	$63,478					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	12 DS-3s	Milwaukee (2 units)	$85,680					
GVG	Additional 8-port cards (3)	Fiber	Digital		Milwaukee (3 cards)	$10,734					
GVG	Major Node Switching Equip	Fiber	Digital	16 DS-3s	Appleton	$63,478					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	12 DS-3s	Appleton (3 units)	$128,520					
GVG	Additional 8-port cards (7)	Fiber	Digital		Appleton (7 cards)	$25,046					
GVG	Major Node Switching Equip	Fiber	Digital	16 DS-3s	Wausau	$63,478					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	12 DS-3s	Wausau (2 units)	$85,680					
GVG	Additional 8-port cards (4)	Fiber	Digital		Wausau (4 cards)	$14,312					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Shell Lake (WITC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Shell Lake to Eau Claire(2 units)	$42,840					
GVG	Additional 8-port cards (2)	Fiber	Digital		Shell Lake (2 cards)	$7,156					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Fennimore (SW Tech)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Fennimore to Madison (2)	$42,840					
GVG	Additional 8-port cards (1)	Fiber	Digital		Fennimore (1 card)	$3,578					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Janesville (Blackhawk TC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Janesville to Madison (2)	$42,840					
GVG	Additional 8-port cards (1)	Fiber	Digital		Janesville (1 card)	$3,578					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Kenosha (Gateway TC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Kenosha to Milwaukee (2)	$42,840					
GVG	Additional 8-port cards (1)	Fiber	Digital		Kenosha (1 card)	$3,578					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Fond Du Lac (Moraine Park TC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Fond Du Lac to Appleton (2)	$42,840					

This price was determined by estimating the full construction cost of the fiber to all locations, and then pro-rating the portion of the fiber that we would anticipate using (i.e. 12 DS-3s to the major nodes, 6 DS-3s to the secondary nodes, and 3 DS-3s to the endpoints).

Prices for the equipment include installation, figured at 11% of full retail price. Also reflects a discount of 40% off list price, which should be easily achievable. For the OC12 FOTS, 15% for install and 10% discount figures are used.

462

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BEST COPY AVAILABLE

OVERLAY.XLS: WECB Interconnect Configuration Options

									Lease		
Vendor	Product	Type	Mode	Bandwidth	Route	Purchase	Term	Inst Access	Access/Mo	Operate/Mo	TOTAL
GVG	Additional 8-port cards (2)	Fiber	Digital		Fond Du Lac (2 cards)	$7,156					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Sheboygan (Lakeshore TC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Sheboygan to Appleton (2)	$42,840					
GVG	Additional 8-port cards (1)	Fiber	Digital		Sheboygan (1 card)	$3,578					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Green Bay (Northeast TC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Green Bay to Appleton (2)	$42,840					
GVG	Additional 8-port cards (1)	Fiber	Digital		Green Bay (1 card)	$3,578					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Wisconsin Rapids (Midstate TC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Wisconsin Rapids to Wausau (2)	$42,840					
GVG	Additional 8-port cards (1)	Fiber	Digital		Wisconsin Rapids (1 card)	$3,578					
GVG	Secondary Node Switching Equip	Fiber	Digital	8 DS-3s	Rhinelander (Nicolet TC)	$59,899					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	6 DS-3s	Rhinelander to Wausau (2)	$42,840					
GVG	Additional 8-port cards (1)	Fiber	Digital		Rhinelander (1 card)	$3,578					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Superior to Shell Lake (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Ashland to Shell Lake (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	New Richmond to Shell Lake (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Cumberland to Shell Lake (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Rice Lake to Shell Lake (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	River Falls to Eau Claire (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Menomonie to Eau Claire (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Ladysmith to Eau Claire (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Chippewa Falls to Eau Claire (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Independence to La Crosse (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Tomah to La Crosse (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Mauston to La Crosse (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Viroqua to La Crosse (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Richland Center to Fennimore (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Platteville to Fennimore (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Reedsburg to Madison (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Portage to Madison (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Watertown to Madison (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Fort Atkinson to Madison (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Monroe to Janesville (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Beloit to Janesville (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Milton to Janesville (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Whitewater to Janesville (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Elkhorn to Kenosha (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Racine to Kenosha (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Oak Creek to Milwaukee (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Waukesha to Milwaukee (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Pewaukee to Milwaukee (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Mequon to Milwaukee (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	West Allis to Milwaukee (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Ripon to Fond Du Lac (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Fox Lake to Fond Du Lac (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Waupun to Fond Du Lac (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Beaver Dam to Fond Du Lac (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	West Bend to Fond Du Lac (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Manitowoc to Sheboygan (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Cleveland to Sheboygan (2)	$21,420					

APPENDIX P-6

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OVERLAY.XLS: WECB Interconnect Configuration Options

Vendor	Product	Type	Mode	Bandwidth	Route	Purchase	Term	Lease Inst Access	Access/Mo	Operate/Mo	TOTAL
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Oshkosh to Appleton (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Neenah to Appleton (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Chilton to Appleton (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Clintonville to Appleton(2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Wautoma to Appleton (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Gillett to Green Bay (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Marinette to Green Bay (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Sturgeon Bay to Green Bay (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Marshfield to Wis Rapids (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Adams Fndshp to Wis Rapids (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Stevens Point to Wis Rapids (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Medford to Wausau (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Phillips to Wausau (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Antigo to Wausau (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Whittenberg to Wausau (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Minoqua to Rhinelander (2)	$21,420					
GVG	Multiplexer, Fiber (FOTS) OC12	Fiber	Digital	3 DS-3s	Tomahawk to Rhinelander (2)	$21,420					
	Total Recurring Equipment Charges (mo)								$0	$0	$0
	Total Non-Recurring Equipment Charges					$3,194,345		$0			$3,194,345
Other Information											
	Consulting Services										
	Maintenance Contracts										
	Total Recurring Other Charges (mo)								$0	$0	$0
	Total Non-Recurring Other Charges					$0		$0			$0
	Grand Total Recurring Charges (mo)								*$0*	*$0*	*$0*
	Grand Total Non-Recurring Charges					*$6,047,525*		*$0*			*$6,047,525*
			Amortized Non-Recurring Cost Payments Per Month			*Num Of Years:*	7			*$97,299*	
						Annual Rate:	9%				
								Total Monthly Costs w/ Lease:			$97,299

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APPENDIX P-7

APPENDIX Q-1

WECB Distance Education Technology Study

Contents Of Study Database

One of Evans Associates' deliverables for the contracted Distance Education Technology Study is the submittal of a computerized database of all information collected during the study. The following document summarizes the files that have been put together to date. Please review this material with an eye toward whether this represents the body of knowledge which should be kept in a Distance Education Technology database. What else might be included? What types of questions would users be likely to ask, and can the answers be determined from this database? We will discuss these topics at the DETIC meeting on November 10.

Trade-Related Files

ASSNS:	Organizations and membership groups associated with distance education.
JOURNALS:	Magazines & journals dealing with distance education and technology issues.
MEETINGS:	Distance education meetings and conferences.

Educational Institutions

CONTACTS:	Contact information on all educational institution personnel who participated in the survey and interview process **except** K-12 representatives.
K12S:	Compilation of all Wisconsin K-12 schools, including contact information.
K12DISTR:	K-12 district administrators.
VTAE:	Which VTAE district serves each city in Wisconsin.

WECB Distance Education Technology Study

Contents Of Study Database

Telecommunications Providers

CABLCHAN:	Public TV & school access channels offered by cable TV systems.
CABLECO:	Cable companies in Wisconsin.
CABLSCHL:	Schools that are served by cable TV systems.
CABLSERV:	Which cable company services each city in Wisconsin.
FM:	Commercial FM stations in Wisconsin.
IXCS:	Inter-Exchange Carriers in Wisconsin.
LECEXCHS:	Which LEC services each telephone exchange in the state.
LECS:	Local Exchange Carriers (local telephone companies) in Wisconsin.
PROVIDER:	Telecommunications equipment vendors.

Infrastructure

CITIES:	Information on Wisconsin cities.
LIBRARY:	Library systems in Wisconsin.
SYSTEMS:	Planned or actual distance education systems in Wisconsin.
TOWERS:	Inventory of towers in Wisconsin.

Other

DBUPDATE:	Contacts for keeping database current.
Glossary:	Glossary of Dist Ed terms (WordPerfect format)
LEGLTORS:	Wisconsin legislators by district

APPENDIX Q-3

WECB Distance Education Technology Study

Contents Of Study Database

Discussion: Database Priorities

Very early in this project, discussions among DETIC members were held relative to what the database should contain. The DETIC members came up with a complete list of what they thought the database could possibly contain, and prioritized the list. Larry Dickerson presented the results in a memo dated February 17, 1992. In this memo, Larry pointed out that " (the committee's) primary interest is that database design will be able to accommodate the addition of this kind of information at a later date - not that you collect it all at this time". Keeping that in mind, below is a list (in descending priority order) of the major catagories of information which the committee wanted to see in the database:

1) **Costs**
2) Situational Analysis
3) Technologies
4) **Cities Info**
5) **Existing Distance Education Projects**
6) **Telecommunications Providers**
7) **Contacts**
8) Interconnection Systems
9) Funding
10) Programming
11) Production
12) Regulations
13) **Distance Education Resources**
14) **Tower Info**

At this point, the above items in bold are present in the database. Among those catagories not yet covered, several have been discussed and regarded as not of primary concern for this database because the data exists elsewhere (funding, regulations). Others are good ideas that fall somewhat outside the scope of a technology study (programming, production). Others could be accomplished through the creation of analytical software which would operate on the data already present (situational analysis, interconnection systems).

At this point, I believe that our emphasis should be on making the raw data we have as accurate and complete as possible.

\dbfiles.doc 12/09/92

EVANS ASSOCIATES
Consulting Engineers

WISCONSIN EDUCATIONAL COMMUNICATIONS BOARD
STATEMENT OF STANDARDS
FOR DISTANCE EDUCATION EQUIPMENT
AND WIDE-BAND VIDEO, DATA AND VOICE DELIVERY SYSTEMS

Prepared by:
Evans Associates
Consulting TeleCommunications Engineers
re:
The Wisconsin Distance Education Study

I. LEASE STANDARDS

1. The network delivery system should not be designed by the entity providing the lease. A consulting engineer representing the lessee should design and specify the system, as well as conduct vendor evaluations, negotiations, and proofs of performance.

2. Lease periods should be as short as is financially viable. If periods longer than five years are required for economic reasons, the following special provisions should be included in the lease:

   a. The current ten year contract term requested by some distance education vendors may be an excessively long period to be committed to a single technology. Seven years, with a three year option to renew, should be the maximum contract commitment. This time period is sufficient for the vendor to recover his capital costs. If longer term contracts are required for reasons of cost per year, the contract should contain re-opener language when certain technical milestones are reached, or should contain a contract "buy-out" provision. Also, WECB may agree to a longer lease in return for other concessions. For example, the vendor should agree to provide "not to exceed" prices for each year of the contract for additional T-1 and video channels. Another example is that WECB must have the right to multiplex additional signals on existing channels without incurring an additional cost obligation.

   b. The lessee will have the right to specify the terminal equipment to be used, such as codecs, multiplexers, switches and network software.

   c. At the end of the lease term, such terminal equipment will belong to the lessee at a known buy-out cost. The lessor will continue to maintain the equipment at a known cost on a year-to-year basis.

   d. During the life of the lease, it will be the right of the lessee to specify upgrades to existing terminal equipment as well as the additions of optional equipment, enhancements and/or increases in capacity at prices which reflect the cost of the equipment installed plus a reasonable cost for installation and maintenance. Equipment removed remains the property of the lessee unless an appropriate lease credit is given; the lessee will then have the right to install such replaced equipment at another location.

   e) The entire cost of the network should not be paid in advance. Bonding authority, if used, should be employed as a means of self-financing a timed payout schedule. A pricing formula should also be included so that it is known in advance approximately how much additional capacity will cost once the contract is in force.

f) All distance education contracts should contain escape clauses and waivers to provide adequate flexibility to cover technology obsolescence. For example, a "Most Favored Nation" clause states that for a certain period of time after signing the contract, the lowest price is guaranteed. This means that if the network manager discovers that the same type of integrated network service has been purchased from the same vendor for less money elsewhere (under the same conditions), the vendor will refund the difference. This technique assures that the contracting agency has received the least expensive contract price. It is true that defining "sameness" can be tricky; therefore a proper formula based upon miles, system capacity, and other pertinent factors should be agreed upon prior to contract signing.

3. Lease terms should make it clear that *bandwidth* is being leased, not *transportation services*. Whatever bandwidth increment is being leased (DS-1, DS-3, 20 MHz) should be the **exclusive property** of the lessee during the lease term; no additional cost can be assessed for additional uses of the increment which fit within the designated bandwidth other than for required terminal equipment. For instance, a DS-3 (45 Mbs) lease initially used for 36 Mbs video could not specify additional transportation costs for "overhead" DS-1s or DS-0s used for data or telephone circuits.

4. Lessee should have the right to do their own multiplexing and to utilize their own terminal equipment after the initial equipment is paid for, which could occur at any time during the lease.

5. There should be a specified cost for additional lease increments during the lease period. For instance, if a DS-3 is being leased, the maximum cost for additional DS-3s should be specified for each year of the lease term. If the standard price is lower when the milestone is reached, the lessee would receive the lower cost.

6. The lessee will have the right to employ any multiplexing he deems appropriate on his side of the demarc. For instance, 1X2 or 1X4 frame multiplexing could be used on one 36 Mbs video channel with no cost increase.

7. The lease would have a provision allowing it to be assumed by a central leasing authority if one is established in the state.

8. An engineering study should be conducted to determine whether switches, terminal equipment and software utilized by other entities can be utilized to reduce the cost of the leased network.

9. Assuming that a suitable agreement can be worked out with the appropriate regulatory agencies, subsequent users who employ fiber routes initially installed by individual consortiums for distance education purposes will reimburse the consortium for a proportionate share of the capital costs (pioneer's consideration). Alternatively, the pioneer's preference could be given at the front end based upon the vendor's estimate of future demand on the newly constructed circuit. Conceivably, investor-owned carriers could also find a role for the company's investors so as to further reduce the cost of new fiber without substantially increasing the rate base. A "most favored nation" clause, if obtainable, would allow fiber lease rates to decrease over time as lower rates are established in the WECB service area.

10. The WECB network manager should make every effort to act as a centralized leasing agency and secure network facilities that will provide user control of bandwidth at the lowest possible aggregate cost. An arrangement of this type will eliminate charges for the network during periods when it is not being used. Other area consortia should be contacted to help determine whether WECB's requests can be integrated with those of other entities to provide a lower cost.

11. Wherever possible, the contract should contain terms agreeing to maintain minimum levels of service for the life of the contract. For example, the WECB's network manager may agree to maintain a DS-3 facility on the network backbone for the life of the contract. WECB, at its option, should then have the right to

continually groom the network (employ the proper mix of service slots within the DS-3) and incorporate less expensive facilities into vendor's switches in addition to the contracted minimum if they are available from other sources at more favorable rates.

12. The contract should describe the pricing mechanism to be used for adding and deleting sites and channels. It is important to note that an evolving network may be able to add new endpoints in several different ways (from more than one switch). The least expensive option should be employed, consistent with required flexibility.

13. Codecs and multiplexing equipment, whether leased or purchased for use on the user premises, should be flexible enough to upgrade to SONET, wider bandwidths, and alternate video/data/audio allocations. Users should have access to the codecs both physically and through monitoring software. If WECB asks that leased terminal equipment be replaced for any reason (maintenance concerns, capabilities of newer models, etc), then the new equipment should be added to the lease at the then-current price (i.e. at the time of the replacement). Also, WECB should have the option of keeping the old (removed) equipment and using it elsewhere in their network.

II. VIDEO SYSTEM PERFORMANCE

1. **Response**: For 4.2 MHz frequency response testing, the reference level is 1.25 MHz above the lower frequency boundary of the channel.

   Response variation for all video channels utilizing *any modulating frequency, RGB or component formats* will be +/- 2 dB maximum within each channel; +/- 1.5 dB is recommended if achievable. These limits shall apply from 0.50 MHz to 5.25 MHz above the lower frequency boundary of the channel.

2. **Ghosting:** If ghosting due to reflections or mismatched terminations in the video system is defined as objectionable as defined by the chart below, the source of the reflection will be identified and eliminated:

MAXIMUM TIME DELAY (nanoseconds)	GHOST AMPLITUDE (ref: normal signal)
25 ns or less	- 3 dB
80	-10
270	-20
920	-30
2000	-40

   Interpolation may be affected by drawing the above as a smooth, second order curve.

   Ghosting caused by direct set pick-up will be consistent with the state of the art; new sets will use only coaxial tuner attachments and internal wiring.

3. **Overall Picture Quality:** No visible components of cross-modulation distortion or interference shall be visible (less than 2 IRE for pulse phenomena, less than 1.5 IRE for continuous interference).

4. **Signal-to-Cross Modulation:** Nominally, signal to cross-modulation shall be maintained at -65 dB or better over the operating temperature range.

5. **Second Order Distortion:** Second order products will be attenuated at least -65 dB.

6. **Discrete Triple Beat:** Discrete triple beats will be attenuated better than -70 dB.

7. **Composite Triple Beat:** Composite triple beats shall be attenuated at least -65 dB over the operating temperature range.

8. **Aural Signal Levels:** Aural signals accompanying video programming shall be maintained at -14 dB relative to the visual carrier +/- 2 dB when modulated.

9. **Level of Spurious Discrete Signals:** All spurious signals not mentioned above shall be attenuated at least -65 dB if located within the occupied channel bandwidth, and
   -45 dB if located outside the occupied bandwidth but within the acceptance bandpass of the video amplifying equipment employed.

III. MICROWAVE SYSTEM PERFORMANCE

1. **Frequency Allocations:**

   a. **AM Microwave:** The CARS band (12,700.5 to 12,946.5 MHz) and ITFS point-to-point systems (2.5 GHz) utilize *AM Modulation.* The microwave contractor, with the assistance of the owner's engineer, shall provide all data as required for FCC permits and the approvals of other regulating and frequency coordinating agencies. It should be noted that ITFS frequencies can only be licensed to legitimate educational entities, while CARS frequencies can only be licensed to Cable TV systems. These coordinating activities shall be conducted so that minimal impact is caused to other existing and potential uses by other licensees, according to the Wisconsin ITFS plan. At the same time, future expansion and possible digital modulation should be considered in the assignment of frequencies.

   b. **FM Microwave**: FM microwave can be employed in the following services which are of interest to the State of WIsconsin transportation network:

      - Private Radio Service
      - Common Carrier Microwave Service
      - Broadcast Auxiliary Service

      For the Private Microwave Service, usage within urbanized areas is restricted to 18 GHz and 23 GHz for most applicants. Care should be taken in assigning 18 and 23 GHz frequencies to path lengths in excess of 11 and 9 miles respectively. All frequencies should be assigned in a manner which respects the future requirements of other nearby users.

      Frequency allocations in the Common Carrier Service is the responsibility of the vendor; however, every attempt should be made to utilize clear frequencies and high-performance antennas to minimize future interference. Frequencies may be re-used at relay sites, but co-channel interference specifications must be maintained by vertical separation or other means. If digital transmission is contemplated, care should be taken in utilizing the 2.5 GHz frequency band, which is not channelized in a manner compatible with many digital transmission standards.

      The Broadcast Auxiliary Service provides frequencies in the 2.5 GHz, 6 GHz and 11 GHz ranges. These frequencies can only be assigned to licensees of television facilities. Note: these frequencies are adjacent to the Public Safety Microwave Service used by the Wisconsin Department of Transportation. Combining these frequencies on the same path may offer significant cost reductions, but care must be taken to ensure integrity of both systems.

c. **Other Modulation Methods**: Advanced modulation techniques such as PCM can be used to extend the capabilities of microwave systems consistent with these specifications and FCC Rules.

2. **Performance Specifications and Proof Requirements:**

a. **Video and Data Circuit Usage:** AM microwave shall not be used to carry broadcast quality signals (Level 1 or Level 2), or to carry data circuits with a BER reliability requirement of 10^{-7} or better.

FM Microwave may be used to carry all levels of video programming.

b. **Signal-to-Noise Ratio**: The Signal-to-Noise Ratio for each channel employing AM modulation shall be maintained at 50 dB throughout the system, not including interference from other stations. Interfering signals shall be at lease 45 dB below picture carrier.

For FM modulation, the signal-to-noise ratio shall be 65 dB, with interfering signals at least 60 dB below picture carrier.

c. **Cross Modulation**: Cross Modulation for AM and FM modulation shall be -80 dB or better using the NCTA test method.

d. **Distortion Products:** Second and Third Order Distortion Products shall be -58 dB or better for both AM and FM modulation.

e. **Frequency Stability:** All frequencies shall be adjusted to within FCC specifications as tabulated in CFR Part 7x of the Rules. Measurements shall be made on all transmitting equipment on two separate occasions, at least 48 hours apart, in order to ascertain frequency stability.

f. **Power Output:** Power Output shall be within 5% of the design level.

g. **Hum Modulation**: Hum Modulation shall be less than l% throughout the system for all types of microwave systems.

h. **Fade Margin**: For analog signals and all modulation modes, the appropriate fade margin will be calculated by the contractor and verified by the owner's engineer for each path. Contractor must guarantee the fade margin for each path as required to meet the stated reliability goal. For digital signals, the worst-case BER shall be calculated while employing estimated yearly air diffraction and attenuation factors from the U.S. Meteorological Services North American Database. An appropriate "K" factor shall be used for each path, and the value assumed should be prominently stated on the path calculation forms.

i. **Path Clearance:** Path profiles shall be presented for each path, prepared from the U.S.G.S. 3 arc-second database. Tree and building information shall be obtained from 7.5 minute topographic maps, which shall also be used to check the accuracy of the digital database in cases of rapidly-changing terrain.

Fresnel clearance of 0.6 shall be maintained over all obstructions; over-water paths should maintain greater clearance and employ diversity receiving and/or dual polarization as appropriate. The design engineer should note that attenuation of horizontally polarized signals is not the same as vertically polarized signals for the purposes of establishing path reliability under difficult environmental conditions.
All paths MUST be visually verified before towers are constructed, to ensure there are no obstructions or reflective objects. If possible, signal levels should similarly be verified using a temporary crane or cherry picker as an antenna supporting structure.

j. **Waveguide and Transmission Line:** Coaxial transmission line for Wisconsin state-owned microwave systems should only be used on frequencies below 4 GHz, and then only low-loss nitrogen-filled line should be used.

Elliptical or rectangular waveguide is preferred for most uses, but circular waveguide may be used if a proper maintenance program is in place.

Waveguides shall be pressurized to approximately 4 psi. No discernable drop in pressure shall occur over a 60 hour period with the nitrogen tank turned off. The contractor or common carrier must satisfactorily demonstrate that an efficient and capable maintenance staff is available, and that frequent preventative maintenance is performed.

k. **Cochannel and Adjacent Channel Interference:** Should visible components of picture distortion caused by adjacent or cochannel interference be evident when viewed on a standard color receiver connected to the output of the AM or FM microwave video demodulators, one or more of the following remedies shall be instituted as required to reduce interference so much as possible:

1. If co-channel interference is received at more than 10° azimuth off of main beam, a high performance shrouded antenna shall be used.
2. If co-channel interference is received at other azimuth angles, polarity shall be adjusted or new frequencies shall be coordinated.
3. If adjacent-channel interference is received at an azimuth of less than 10 degrees off of the main beam, a similar high-performance antenna shall be specified.
4. High-Q traps and/or filters shall be employed in cases where residual adjacent channel interference remains after performing the above steps. TRAPS OR FILTERS SHALL NOT BE INSTALLED AFTER PREAMPLIFIERS.

IV. LIGHT FIBER SYSTEM PERFORMANCE

1. **Splices:** Splices to both multimode and singlemode fiber shall be accomplished with a loss of less than 1.0 dB at the operating frequency.
2. Other standards apply as per the video and coaxial calbe sections of this document.

Specifictions for Audio Performance

1. 15 KHz channels
   a. Audio Frequency Response: +/- 1.0 dB (50 Hz to 15 KHz)
   b. Input Level: +18 dBm peak from 600 ohms balanced (+8 dBm normal level)
   c. Output Level: +18 dBm peak into 600 ohms balanced (+ 8 dBm normal level)
   d. Audio Signal to Noise Ratio: 75 dB relative to +18 dBm output level
   e. Crosstalk from all other channels: -75 dB relative to +18 dBm output level
   f. Total Harmonic Distortion @ +18 dBm: 1.0% maximum (50 Hz to 125 Hz); 0.5 % maximum (125 Hz to 15 Khz)
   g. Intermodulation Distortion: 1.0% maximum 60/7000 Hz 4:1 ratio
   h. Balance: Between stereo paris within 0.5 dB

- i. Gain Stability: 0.5 dB
- j. Frequency Response (Stereo summation of 2 channels): +/- 1.5 dB (50 to 15000 Hz)
- k. Phase difference between stereo channel pairs: 5° maximum at 10 KHz
- l. Differential Picture-Sound Delay (TV) 10 Milliseconds maximum

2. 7.5 KHz channels

- a. Audio Frequency Response: +/- 1.0 dB (50 Hz - 7.5 KHz)
- b. Input Level: +18 dBm peak from 600 ohms balanced (+8 dBm normal level)
- c. Output Level: +18 dBm peak into 600 ohms balanced (+8 dBm normal level)
- d. Audio Signal to Noise Ratio: 60 dB relative to +18 dBm output level
- e. Crosstalk from all other channels: -60 dB relative to +18 dBm output level
- f. Total Hormonic Distortion @ +18 dBm: 1.0% maximum (50 Hz to 125 Hz); 0.5 maximum (125 Hz to 7.5 KHz)
- g. Intermodulation Distortion: 1.0% maximum 60/7000 Hz 4:1 ratio

Specifications for Video Performance

Intermodulation Distortion (2 Tone, 3rd Order)
At +12 dBm0 Test Levels - +/- 0.3%

Group Delay Distortion	
50 Hz to 300 Hz:	<500 microseconds
300 Hz to 8 KHz (8 KHz Operation):	<200 microseconds
300 Hz to 10 KHz (15 KHz Operation):	<200 microseconds
10 KHz to 15 KHz (15 KHz Operation):	<300 microseconds
Insertion Gain:	+/- 0.25 dB/24 hours
Interchannel Phase Difference	
1000 Hz	<1°
50 Hz to Nom. Bandwidth	<3°
Signal-to-Crosstalk Ratio (Single Adjacent Channel)	75 dB ref. APL
Impedance:	600 ohms/150 ohms balanced
Return Loss (50 Hz to Nom. Bandwidth)	>26 dB
Longitudinal Balance (IEEE Method) 50 Hz to Nom. Bandwidth	>50 dB
Environment:	
Storage Temperature	-40° to +70°C
Specification Temperature	0° to +50°C
Humidity	95% maximum, non-condensing
Storage Altitude	12,200 meters (40,000') ASL
Specifications Altitude	3050 meters (10,000') ASL
Power Requirements	
Standard	+5, +/- 15 and - 48 vdc

Note 1: At frequencies higher than 1 KHz, level must be reduced because of pre-emphasis.

Note 2: Performance was measured under the following conditions:
1) Cable Equalizer switched out
2) Pre-Emphasis switched in
3) De-Emphasis switched in
4) Transmit attenuators set at +15
5) Receive attenuators set at 0

V. COAXIAL CABLE SYSTEM PERFORMANCE

1. **On-Site Testing:** On-site inspection and testing will be conducted by the owner's engineer for all dedicated cable as construction progresses. Critical subsystems will be tested and approved before work is begun on further systems. The inspection schedule will be drawn up and approved in advance by the owner and all contractors, and no delay will be occasioned because of it. Examples of subsystems to be so tested during construction are, but are not limited to:

   a. TDR testing each cable to ensure return loss of better than 35 dB.

   b. Measure cable attenuation and leakage for conformance with design goals and FCC specifications.

2. **System Performance Proof:** Upon substantial completion of the Cable system, and the system has been tuned up and balanced, an operating test for approval will be conducted. Such test for approval shall involve all components of the delivery system. All contractors shall be present for this test, along with the owner's engineer.

   At a minimum, tests should be made for signal level, tilt, visible distortions, and other disturbances using a calibrated field strength meter, a Spectrum Analyzer, a color receiver along with a sweep generator and appropriate detector as follows:

   a. **Sweep Test:** The sweep generator is adjusted to provide a sweep which spans the range to utilize on the system. The detector and scope are calibrated, and response deviation read directly on the scope screen.

   b. **Carrier-to-Noise Ratio:** A continuous wave (CW) source is connected to the system input on the frequency of each channel to be used. A spectrum analyzer is set to the proper sweep and intermediate frequency (IF) bandwidths, and a reference reading taken. CW power is removed, and uncorrected carrier-to-noise (C/N) is read from the analyzer screen. For video, 13 dB is then subtracted from this reading to correct the ratio for a 4 MHz bandwidth. Appropriate Bessell corrections will be made for FM modulation.

   c. **Cross-Modulation:** A special test source is used at the appropriate test location to provide 100% synchronous square-wave modulation on all channels simultaneously. An appropriate detector shall be used to measure modulation on each channel due to the other channels.

   The spectrum analyzer is adjusted to each channel in turn, adjusted as a linear receiver with a 100 KHz bandwidth. A voltmeter, phase-locked to the analyzer, is then adjusted for 100% reference deflection. Modulation is then removed only on the test channel, and residual modulation is read on the voltmeter. Cross-Modulation will be -50 dB at balance temperature, and -46 dB over the operating temperature range. This specification will apply to all channels.

d. **Signal Levels:** Read directly from the field strength meter.

Subscriber Visual Signal Levels shall conform to the following chart:

Frequency	Minimum level	Maximum level	Adjacent channel flatness
54- 216 MHz	8 dBmv	20 dBmv	+/- 3 dB
216 - 260	5	15	+/- 3 dB
260 - 300	1	15	+/- 3 dB
300 up	1	15	+/- 3 dB

Signal level measurements will be taken through the maximum frequency proposed by the design criteria, with all channels active. Measurements will be corrected for the bandwidth of the measuring equipment to reflect 4.2 MHz S/N (or other bandwidth as appropriate to the system in use). Each channel shall be measured individually.

e. **Aural Signal Levels:** The aural signal shall be maintained at -14 dB relative to the associated visual carrier, with a tolerance of +/- 2 dB.

f. **Carrier level baseband variation:** +/- 6 dB any two channels in the range of 54 to 216 MHz. All visual carriers in the range of 216 - 500 MHz shall be within 10 dB of channel 13, and within 12 dB of any other channel.

These limits shall apply over the design temperature range of the cable system. Contractor shall take special precautions to ensure that the accuracy of equalization and thermal compensation all guarantees these levels will be met throughout the year.

These values reflect the Subscriber tap measurement. They are not intended to prohibit any one tilt method.

g. **PIX and Sound Quality:** Picture quality shall be observed, and there shall be no visible components on cross modulation, beats, co-channel interference, or ghosting on any channel, with all channels active.

h. **Hum Modulation:** Conducted with a CW source and the spectrum analyzer on any one channel. The reference level is set and the residual hum observed on the screen. Modulation due to Power Frequencies *and other low frequency disturbances* shall be less than -42 dB at the balance temperature, and less than -38 dB over the temperature range at all locations and on all channels.

i. Other tests, such as carrier-to-triple beat, may be ordered by the owner's engineer, if warranted. These tests shall employ the spectrum analyzer and other above-named test equipment, as well as network analyzers and waveform monitors, as appropriate.

Should such a demonstration of performance show that the system is not properly configured or adjusted, the affected contractors shall make all required adjustments and repairs, and a proof of performance arranged for each system component, and for each test failed, as well as all other components and tests which could be affected by the adjustments and/or repairs so ordered.

3. **Differential Phase and Gain:** All video cable must be adequately compensated for differential phase and gain.

4. **Amplifier Types:** In general, systems using Trunk Amplifier/Bridger combinations are to be preferred over mid-span bridgers. Line extenders should be used sparingly, although it is recognized that some will be required to span long rural feeders. No pressure taps will be allowed.

Response flatness is not specified, but care should be used so as to not cascade to an unintentional tilt. Limited use of tilt attenuators, such as the RMS Electronics CA-2200, will be allowed; they should not be relied upon to correct design errors.

5. **Signal-to-Noise Ratios:** The following Signal-to-Noise Ratios will be maintained at points where the signal will be delivered to the owner's facilities:

Frequency	Trunk Cable Measurement		Subscriber Tap Measurement	
MHz	ba'l temp	over temp	ba'l temp	over temp
54- 216	- 46 dB	- 46 dB	- 40 dB	- 38 dB
216 - 260	- 43 dB	- 41 dB	- 38 dB	- 36 dB
260 - 300	- 42 dB	- 40 dB	- 36 dB	- 35 dB
300 up	- 42 dB	- 40 dB	- 26 dB	- 35 dB

These measurements shall be made via the carrier-to-noise method, by terminating the headend amplifier inputs. Noise contributions by atmospherics and other outside influences shall be minimized at the time of antenna installation, and shall not be a part of this test.

These signal-to-noise specifications have been designed to accommodate the requirements of relatively long Cascades (up to 17 miles). It is anticipated that these figures will be better for the shorter Cascades.

6. **Frequency Tolerance for Cable Generators:** The Frequency Tolerances of remodulating generators shall be as follows:

Visual Carriers and standby carrier generators: +/- 10 KHz
Visual-Aural Intercarriers: +/- 1 KHz
Cable Equalizing Carriers (if used): +/- 20 KHz

7. **Specifications for Cable Electromagnetic Radiation:** Radiation from the cable system shall meet the requirements contained in Part 76.605 (a) (12) of the FCC's Rules and Regulations. Such radiation shall be measured in accordance with Part 76.609 (h). In general, the cable system shall have absolute RF integrity, and shall resist ingress by foreign signals, especially via subscriber drop terminals. Proper grounding techniques and extensive shielding will be required to minimize pickup at HF frequencies, especially 27 MHz CB band.

8. **Impedance of Signal Transmission System and Cable:** All devices: 75 ohms nominally, +/- 2 ohms. Test equipment may employ 50 ohm impedance with proper minimum-loss pad.

9. **Specifications for Passive Devices:**

   a. **Passband**: At least 5 MHz to 500 MHz for all devices or such extended requirement as may be necessary in the highest-capacity systems. In general, it should not be necessary to change splitters, taps, or pads presently installed in the system to affect 2-way operation in future phases in order to obtain wider frequency response.

   In cases where separate paths are to be used for upstream and downstream signals, the response of the upstream devices may appropriate for the cross-over system used.

   b. **Isolation:** Tap-to-tap isolation over the operating frequency range will be at least 20 dB minimum for all devices. Output to tap isolation will be 25 dB minimum for all devices, while output-to-output isolation for splitters will be better than 20 dB. Only DIRECTIONAL COUPLERS may be used as taps. Return Loss for all devices must be 20 dB for all ports over the operating frequency range.

c. **Current Capacity:** The current carrying capacity of all devices will be sized as required to accommodate future expansion of the cable system to limits of the signal-to-noise criteria.

d. **Static Protection:** A grounding bracket shall be used at each user drop. Unit is to have no more than 2 picofarads of capacitance. F-connectors and splices located in drop cable shall be suitably protected against moisture and corrosion through use of weather boots or other approved techniques.

Detailed specifications for individual devices are as follows:

- Splitters: 80 dB shielding, 3.6 dB splitting loss for 2-way unit
- Fixed Attenuators: Return loss of 20 dB
- Filters and Traps: High-Q shielded dual lumped constant units; interconnection to be effected with double-shielded cable
- Transformers (75Ω to 300Ω): AC and DC isolated, shielded unit. Insertion loss over operating frequencies =.6 dB maximum.

Directional Couplers: Nominal insertion loss approximately as per the following table over the operating frequency range:

Nominal Coupling Loss (dB)		Insertion Loss (dB)	
(4-way)	(2-way)	(4-way)	(2-way)
6	7	2.2	4.1
9	10	1.5	1.8
12	13	1.2	1.4
16	16	1.4	0.8
20	20	0.8	0.8

- Diplexers: Diplexers used to provide input for reverse signals at subscriber locations equipped for 2-way will be subject to the following specifications:

Frequency Range (example for sub-split): Low: 5 to 30 MHz +/- 3 dB
High: 50 to 500 MHz

Return Loss: 18 dB minimum
Insertion Loss: 0.5 dB nominal
Isolation Between Low & High: 35 dB minimum

Differential phase and other crossover distortions shall be consistent with the state of the art.

e. **Future Expandability:** Locations of taps, as well as sizes and numbers of outlets shall be selected with future expansion in mind. Careful selection of tap location and values will be required.

In general, the system shall be so designed that present trunk cable may be extended in an orderly manner so that the signal-to-noise ratio measured on the trunk in each cascade can be maintained.

f. **Degree of Bidirectionality:** It is preferred that bidirectionalizing an amplifier station in the future be accomplished without requiring changes in level adjustments, pads, or equalizers. Likewise, any required line extenders will all be capable of reverse operation, with full active or passive reverse installed in the feeders as required. All losses associated with bidirectional capability should be figured into system design for all Cascades and locations.

g. **Other Requirements for Passive Devices**

- The trunk cable shall not be tapped, and pressure taps will not be allowed anywhere in the system.
- All electronic equipment shall be protected by a corrosion-resistant housing. All equipment, connectors and splices will be located so as to be available for inspection and maintenance.
- All unused outlets, including test point taps (except those on trunk amplifiers designed to operate without termination) will be terminated using an appropriate resistor.
- Appropriate expansion loops will be used in all outdoor cable, and shall be formed in a manner which eliminates the possibility of kinking the cable. Sufficient cable shall be left by the lashing crew to provide a secure connection using industry standard cable routings.

10. **Specifications for Cable Amplifiers**

a. **Minimum frequency Response for Trunk Amplifiers:**

Forward = 50 to 500 MHz +/- 0.3 dB
Reverse = 5 to 30 MHz +/- 0.3 dB (sub split only)

b. **Minimum frequency Response for Bridgers and Extender Amplifiers:**

Forward = 50 to 500 MHz +/- 0.5 dB preferred; 0.75 dB min.
Reverse = 5 to 30 MHz +/- 0.5 dB preferred; 0.75 dB min. (sub split)

c. **Operating Voltage:** 60 VAC 60 Hz. preferred, 30 v acceptable if demonstration is made concerning acceptable cable resistance losses.

d. **Test Points:** Type F preferred.

e. **Ambient OPERATING Temperature Range:** -40° F to 125° F.

f. **Relative Humidity for all outside equipment:** 0 to 100%

g. **Connections for Feeder Cables:** 5/8" X 24 center seize.

IMPORTANT NOTE: So far as is possible, all connectors will be of the center seize type. In addition, sufficient skinned center conductor will extend beyond the female contact to allow for unavoidable contraction in cold weather. It should be remembered that the pull on an average trunk span installed in 80 degree weather can exceed 200 pounds on the center conductor when the temperature drops to -20° F.

h. **Hum:** -60 dB maximum.

i. **Impedance:** 75 ohms.

j. **Trunk Amplifier Spacing:** Between 15 and 22 dB of cable recommended.

k. **Spurious Outputs:** -60 dB or better.

l. **Return Loss (In and Out):** 16 dB or better.

m. **Isolation Forward/Reverse:** At least 70 dB.

n. **40-channel Cross Modulation (forward):** Trunk Stations: -88 dB
Bridger/Extender Amplifiers: -60 dB

o. **3-channel Cross-Modulation (reverse):** Trunk Stations: -88 dB
Bridger/Extender Amplifiers: -60 dB

p. **Noise Figure (with equalization - nominal gain and 500 MHz forward with 30 MHz rev):** Trunk
Amplifiers (forward): ll dB maximum
Amplifiers (reverse): 12 dB
Bridger/Extender Amplifiers (forward): 12 dB
Bridger/Extender Amplifiers (reverse): 12 dB

q. **Trunk Forward Gain:** Not Specified. The final design will seek the best trade-off with cost, gain, cable size, and noise figure for each individual cascade. Typically, gain will be approximately 20 dB at 400 MHz (i.e. 10 dB in, 30 dB out for a 17 dB Cascade with 3 dB flat loss).

r. **AGC and Slope Control:** The amount and extent of AGC is left to the discretion of the contractor, although the complete system must be described in advance. Deviation from system specifications due to thermal effects, weather, and other daily, monthly, seasonal, or yearly variations will not be tolerated. Human gain-riding shall not be considered to be a component in the closed-loop gain control system. In general, it is anticipated that both AGC pilot and slope control will be required to meet these specifications during the course of the year. Variable equalizers may also be used to extend the efficiency of these systems.

s. **Intermodulation (second and third order):**

Trunk Amplifiers: -80 dB or better (forward and reverse)
Bridger and Extender Amplifiers: -68 dB or better (forward and reverse)

t. **Other Requirements:**

- The open lid on all amplifiers is to clear all poles, lines, and other obstacles. Amplifiers hung on a messenger shall be closed with sealing compound. Cable spacers to be used at all poles.
- Cable power supplies shall be surge protected, and located in a position as secure from vandalism as possible. If necessary, power supplies shall be pole mounted at the 8' level, using removable pole steps.
- Power supplies shall be surge protected, and shall maintain their output within 1.5% for line changes of 95V to 130 volts.
- State-of-the-art performance is required for other unspecified parameters such as differential phase and gain.

- Ground drop neutrals will be continuous and unfused. Neutral lines to be bonded to cutout cabinets, and connected to earth ground at base of the pole. Anchor attachments and other hardware shall be grounded at intervals prescribed by the power company, and at dead-ends, via #6 Copper wire.

11. Specifications for Upstream Passive Components and Amplifiers

The technique of coupling upstream data to the trunk line is not specified. However, all devices shall have a passband which represents maximum utilization of the upstream technique employed (sub-split, mid-split, or dual-cable system). Any remaining trunk cable not specified for two-way at system light-up will utilize the same two-way capable amplifiers, with space for future insertion of upstream modules.

Likewise, all feeders and line extenders must be capable of 2-way operation in the future without amplifier replacement. It will be permissible to add such components as additional directional couplers and/or splitters in the future in order to accomplish bidirectionality; however, all losses introduced by these devices must be included in the original design, even though they will not be installed. It should be remembered that all Wisconsin State projects will consist ENTIRELY of bidirectional cable at some point in the future. Accordingly, the ease with which upstream links may be accomplished is a prime consideration.

Special precautions and design criteria must be employed to ensure RFI integrity if sub-split techniques are used for the upstream band. Land Mobile, CB, and Amateur assignments are in this range. RFI tap O-ring moisture seals and RFI sleeve inserts will be necessary.

VSF-type fittings will be provided with a silicone-filled weather boot, or heat-shrink tubing and weather resistant tape.

12. Specifications for Coaxial Trunk, Distribution and Feeder Lines

a. Physical Characteristics

The impedance of all cable shall be 75 ohms, +/- 2 ohms, or as necessary to meet further specifications as outlined below. Cable shall be foam polyethylene or equal construction for trunking and distribution. Cable product mix is not specified, but in general, use of 0.750, 0.500, and 0.412 cable meets design objectives while successfully trading off amplifier costs. Innovative design engineering is especially encouraged in this regard.

Cable Attenuation shall be within 5% of the manufacturer's specified nominal value for type and length involved, and within industry median values for cable type. Examples for foam poly cable are as follows, at the indicated frequencies, in dB per hundred feet):

Cable Size	Nominal Attenuation		Maximum Atten	
	(Ch. 13)	(300 Mhz)	(Ch. 13)	(300 Mhz)
0.750"	0.71	0.86	0.75	0.91
0.500"	1.04	1.24	1.09	1.31
0.412"	1.28	1.55	1.35	1.63

For drop cable, 75 ohm, foam polyethylene, RG-59 type cable with black vinyl or black polyethylene jacket shall be used. Cable shall have a minimum of two foil shields, or one foil and one 55% braid shield, and shall, in any case, meet the specifications contained in part 76.605 (a) (12) of the FCC's Rules and Regulations. Some longer-drops may require the lower-loss RG-6 type drop cable.

Examples of drop cable:

Cable Type	Attenuation
RG-59	(3.7 dB @ channel 13)
RG-6	(2.75 dB @ channel 13)

Note: Figure-8 cable will ONLY be allowed for drop wire.

b. **Electrical Characteristics**

RETURN LOSS: Cable return loss shall be as follows:

Distribution cable: -26 dB 5 to 500 MHz
Drop cable: -20 dB 5 to 500 MHz

TDR: Local discontinuities caused by splicing non-sequential portions of a reel, or by splicing two reels together where one is significantly affected by die draw-down, shall not exceed a reflection coefficient of 0.005p. Installer should take special care to match the characteristic impedance of adjacent reels, and to keep trunk splices to an ABSOLUTE MINIMUM. All trunk cable splices must be approved by the project engineer, both before installation and after, through TDR test.

No cable which exhibits bruises or other shipping damage shall be installed in the system.

c. **Overhead Construction**

The following lashing procedure is recommended for overhead wire, although deviation, for cause, may be permitted if cleared beforehand:

- Trunk messenger shall be 1/4" diameter or larger, high-strength 7-strand galvanized cable.
- Lashing wire shall be O.045" stainless steel, wraps-per-inch and tension varying according to standard industry practice and the size of cable being supported. (4750# wire)
- Cable and messenger shall be installed on the same side of the pole as existing utility wires.
- Cable subject to greater-than-standard tensions, such as longer-than-normal spans or steep grades, shall be double-lashed, or #6000 tensile strength lashing wire shall be used.
- Cable of the same size, but used for different purposes, may be lashed together provided the function of each is clearly marked.
- All cable, if subjected to a corrosive atmosphere, shall be protected with an outer jacket.

d. **Buried Construction**

No underground splices will be permitted. An appropriate pedestal shall be installed if necessary.

All cable to be directly buried shall be subject to the following specifications:

- The cable will be protected with an appropriate flooding compound. Cables installed in ducts or tunnels shall be similarly protected.

- Cables shall be buried at least 18 inches below grade.

- All rock and other debris shall be removed to be greater than 3" below cable depth. Depressions shall be filled with clean earth.

- Under paved roads, cable shall be installed in 2" conduit. Runs of further than 25 feet shall be accompanied by a nylon pull rope.

- Equipment connections and splices shall be of the seized center conductor type.

- Equipment entries shall be provided with expansion and drip loops, as appropriate. Manufacturer's recommended bending radius will be observed; in no case will bends of radii less than 10 times cable diameter be allowed. All splices shall have appropriate expansion joints. All exposed splices, connectors and terminators shall be weatherproofed. Equipment connectors shall be of the O-ring type. Expansion loops at pole attachments will be of the compound curve type (7.5"R .75 cable).

VI: VIDEO RESOLUTION STANDARDS

1. Video Resolution Terminology

Except for supercomputer data rates, video applications consume by far the largest portion of electronic transportation capability. Video requirements therefore most frequently drive system bandwidth design.

The following terminology will be used for the purposes of this document to refer to the various resolution levels required:

Level 1, or High-Definition TV: Horizontal, vertical and time resolution compatible with the FCC's emerging HDTV standards, for use in home theater or medical applications. At present, this resolution level can only be achieved by fiber or coaxial cable employing at least 90 Mbs (2 DS-3).

Level 2, or Broadcast TV: Resolution compatible with usage by today's network television delivery system, for use in demanding educational applications requiring full NTSC and EIA motion standards. This resolution level can be reached by most technologies at the full ("high-cap") DS-3 level.

Level 3, or Credit-Course TV: Resolution compatible with delivery by today's analog cable television systems or by the AM analog microwave technology utilized by Instructional Television Fixed Stations. This resolution level is used for instructional programming employing the maximum flexibility of motion, and is consistent with 34 Mbs or 36 Mbs digital codecs.

Level 4, or Staff Development TV: Resolution compatible with delivery technologies such as Cable TV, fiber, microwave and ITFS whereby two video programs are multiplexed on one traditional broadcast TV channel. For instance, analog transmission employing alternate frame multiplexing is consistent with the Level 4 mode, as is the use of one-eighth of a satellite digital transponder. This resolution level is also referred to as "entertainment quality".

Level 5, or Video Teleconference TV: Resolution compatible with delivery by a single DS-1 digital circuit for use in long-distance meetings and planning sessions. For some "talking heads" applications requiring restricted motion, even lower rates may be employed (down to approximately 128 Kbs). It should be remembered that even at the lower rates it is possible to achieve highly detailed pictures merely by reducing the screen "refresh" rate. This technique is ideal for presenting overhead projector materials or "audiographics" presentations.

2. Network Component Standards

The standards recommended for Wisconsin's distance education backbone network, as well as the local and regional networks, are driven by the basic requirements of Wisconsin users and agencies. The following standards have been selected for each of the five video resolution levels detailed in the previous paragraph, as appropriate to fulfill the needs of the various categories of network users.

For Level 1 (HDTV video) transmission, a 2-DS-3 solution is recommended. Standards would include provisional FCC compatible signals employing a binary coded analog luminance and chrominance channel and a fully digital detail channel. This video level has, to this point, only been requested by hospitals for their training applications.

For Level 2 (TV quality), it is recommended that signals delivered to or received by all sites meet the EIA, NTSC and FCC standards for video quality. Further, the user should adhere to the EIA RS250B specifications for local video production. At the present state of codec development, a full 45 Mbs will be required for digital delivery, although improvements within the next two years are expected to reduce the requirement to 22.5 Mbs.

For credit course video transmission, it is recommended that Level 3 video signals which are delivered to or received by a user site meet all pertinent NTSC standards for video quality consistent with today's 36 or 34 Mbs codecs. Within the next two years, 1/4 DS-3 is expected to support this level of resolution.

For non-credit course video, the resolution available in Level 3 may be decreased by half, for instance by employing alternate-frame multiplexing (Level 4 signals). This would allow the carriage of two programs in the same bandwidth utilized by one credit course.

For teleconferences, a minimum rate of 256 Kbs is recommended as Level 5, with a 384 Kbs maximum. The codec should be able to select the rate which is appropriate to the particular application. Audiographics applications should use ISDN basic rate within a DS-1. This level should also respect standards prepared by the State of Illinois for the HECA grants.

VII. Level 5 (T-1 Compressed Video) System Performance

In order to ensure complete integration of all local and regional systems into the statewide network, it is necessary that rather explicit technical standards for equipment be adopted. Specifically, compressed video coder/decoders (CODECs) should operate at a full T-1 data rate and support 7 KHz of audio as reflected by the following standards:

1. **Compressed Digital Standards for T-1 CODECS:**

H.320 - Narrowband Visual Telephone Systems and Terminal Equipment
H.261 - Video CODEC for Audiovisual Services at Px64 kbps
H.221 - Frame Structure for 64 to 1920 kbps Channels in Audiovisual Teleservices
H.242 - System for Establishing Communications Between Audiovisual Terminals using Digital Channels up to 2048 kbps
H.230 - Frame Synchronous Control and Indication Signals for Audiovisual Systems

The Network interfaces supported include T-1 (DSX-1), EIA RS530 (RS449/422), and CCITT V.35. Line coding options should include both AMI and B8ZS. The H.320 family requires that the video frame rate be 30 frames per second, provide for both NTSC and PAL formats, and provide motion compensation and forward error correction. All CODEC units must operate at Full CIF mode. Remote diagnostics and control should be provided as specified in the applicable CCITT documents.

With any proposal, installation and maintenance costs should be evaluated along with equipment costs. In general, a compatibility chart of CODECs that have passed audio and visual communication interoperability tests with each vendor's H.261 CODEC should be provided for inspection before a codec is purchased.

Each vendor supplying CODECS should submit software and hardware upgrade costs and the frequency with which upgrades occur. Availability and costs for the following enhancements should also be included:

a) Split Screen Unit
b) Encryption
c) NTSC Graphics
d) Data Port Multiplexer
e) V.35 single or dual interfaces
f) Any other add-on enhancements

CODEC transmission speeds lower than 1.536 mbps (fractional T-1) should include the use of a digital network interface that supports transmission rates from 64 kbps to 1.536 mbps at selected 64 kbps increments (Nx64). Where "Switched 56" networks are anticipated, the network interface should support transmission rates from 56 kbps to 1.920 mbps at selected 56 kbps increments (Nx56).

2. Inband Audio Coding in T-1 Video CODECs

Audio usage should be compatible with the following provisions:

- G.711 Coding of 3.4 KHz Audio Signals @ 64 kbps
- G.722 Coding of 7.0 KHz (wideband) Audio Signals @ 48, 56, 64 kbps)

3. Multi-point Control Units (MCUs) for T-1

MCUs must be capable of integrating signals from any H.320 compliant CODEC, providing for a minimum of 2 cascades, and supporting voice actuated and chairman controlled video switching. Remote diagnostics and control should be provided as specified in the applicable CCITT documents.

The following standards apply to MCU units:

H.231	MCUs for Audiovisual Systems using Digital Channels at up to 1.544 mbps to link three or more H.320 CODECs
H.243	Control Procedures linking H.231 MCUs and H.320 CODECs

4. T-1 Vendor-Supplied T-1 Networks and Capabilities

Both switched (dial-up) digital T-1 (1.544 Mbps) services and dedicated services are expected to be used by the Wisconsin network regional facilities. Some of the local networks will obtain access via the public telephone system, while others will utilize private or virtual private networks. All networks must have the capability of employing voice, data and video on the same T-1 increment with 2-way capability.

a) Network Bridging

Vendors should submit a per-minute rate for establishing multipoint dial-up video conferencing through the network. If the bridging equipment is owned by the network, the vendor should be requested to submit a per-minute rate and set-up cost for utilizing said services. Dedicated costs should also be obtained for comparisons.

Vendor proposals include a description of how an on-net and off-net video conference call would be placed through the network from 112 Kbps to full T-1, what network facilities would be used (including CODEC conversion compatibility on an off-net call, and what equipment would be needed from a customer standpoint).

Vendors should be encouraged to explore innovative solutions to realize bandwidth on demand and access on demand (video dial tone).

b) Network Equipment

Vendors should submit purchase, lease, installation and maintenance costs as well as product descriptions and specifications for Customer Provided Equipment (CPE) that meet the requirements listed below.

a) Dynamically allocates bandwidth 'on demand' in 56 Kbps/64 Kbps channels. The equipment must have the capacity to allocate 2 to 24 channels.

b) Bandwidth that can be distributed by automatic, time-of-day, or manual allocation, and including a priority assignment provision.

c) Customer Provided Equipment (CPE) that allows for multiple T-1 access. Specify maximum number of T-1 connections per CPE unit.

d) Backward compatibility with existing CSU/DSU and channel bank products.

e) User interfaces for configuration, session monitoring, and diagnostics.

f) An RS-232 configuration interface, a V.35/RS-449 data interface and RS-366 or V.25 control dial interface. The interface for the video conferencing application shall be a menu-driven mechanism.

g) A redial mechanism for loss of channel connectivity during transmission from 1-24 channels.

h) Provisions in the equipment for reverse multiplexing.

i) CCITT standard QCIF mode shall be supported, plus manufacturer specific mode (i.e. CTX-plus) with 480X 368 30 fps motion compensation.

j) System to be full duplex, with integrated echo cancellation shall be employed.

k) Other optional requirements:

    1) CCITT G.728 audio algoithm spec (16 kbps audio)

2) G.711 audio alorithm
3) Camera pan/tilt/zoom
4) Preset camera control memory positions
5) Picture-in-picture with relocatable window
6) Separate document camera
7) Network interfaces: Switch-56, basic rate ISDN at up to 112/128 Kbs. or: dual V.35(RS-366) or RS-449
8) Upgradable software
9) Support for external VCR and FAX
10) CCITT QCIF(144X176) & FCIF(288X352)
11) RS-449 user data ports for image transfer of high-resolution documents
12) Intergated audio bridge
13) Voice activation mode
14) Capable of operating 3 separate conferences at different rates and different algoritms
15) Switched and dedicated networks
16) Encryption support
17) Hard copy

c. Multipoint Control Unit (Bridging Equipment)

Vendors should submit purchase, lease, installation and maintenance costs for the Multipoint Control Unit. Responses must adhere to the CCITT H.261 standard, and other pertinent CCITT standards. Responses must provide documentation and specifications along with a record of proven field tests and/or installations.

Vendors should specify the maximum number of ports per bridge and the possible configurations per bridge. Additionally the vendor is requested to specify how bridges are 'daisy-chained' or 'cascaded' together, how many ports are expendable for that application, and the maximum number of bridges that can be cascaded. Vendors should explain their proprietary clocking techniques, and how control signaling is used through the bridge for voice, video and chairman control. Vendors should include optional pricing for:

1) Encryption
2) Message Channel Control
3) Other channel interfaces

SCANNING-ONLY SYSTEMS ARE NOT ACCEPTABLE. Quad-split with zoom AND scan should be utilized.

VIII. CLASSROOM/CONFERENCE ROOM DESIGNS

1. The following standards relate to classroom instructional equipment:

   a) A TBC should be used for all signals fed to the overlay network.

   b) Single-clip cameras should be used for instruction and teleconferencing.

   c) Three-chip cameras should be used for DS-3 feeds to broadcast facilities.

2. The following equipment list represents a typical moderate-cost classroom:

LOW COST T1 COMPRESSED VIDEO SYSTEM

Proposed Classroom Equipment Configuration - OPTION 1

	Price
Rembrandt II/VP codec	$26,000.
Application Package	
AP3 (CTX, QCIF,FCIF,CTXPlus)	12,000.
Interface Option	
RS-449/T1/E1/J1 I/F Interface	2,500.
Rembrandt II/VP Feature Options	
Picture-in-Picture	$ 3,000.
G.728 Audio	2,000.
Dual RS-449 User Data Ports	2,500.
Total configuration price	$48,000.
Room Preparation, including:	$ 5,000.
Additional fluorescent lights	
HVAC modifications	
Electrical modifications	
Acoustics (wall coverings & soundproofing)	
Furniture	
Training	$ 1,000.
Installation	$ 5,500.
Gallery Room System	
Dual 25" monitor	2,000.
Total	$61,500.

MEDIUM COST DS-3 DISTANCE EDUCATION CLASSROOM EQUIPMENT- OPTION 2

I. Recommended DS-3 System

1) ElectroHome ECP3101 3-gun Video/Data/Graphics projector with ACON automatic features, including mounting hardware . . . . List: $19,425.

JUSTIFICATION: This is a high quality unit with automatic setup so that no technician is needed beyond initial installation and setup. The unit is capable of projecting computerized data as well as video, as it includes interfaces for both Apple and IBM compatible computers. Once installed, the unit may be removed and installed in other locations. It has superior performance by comparison with the less expensive one-gun liquid crystal display (LCD) projector models.

2) Shure AMS 8000 Audio Mixer and set of eight gated-audio table microphones . . . . List: $4,610.

JUSTIFICATION: This is a state-of-the-art voice response system for student tables or desks which allows hands-free participation, yet discreet voice activation which can be programmed to bypass ambient room noises.

3) Panasonic AG-1740 VHS Videocassette Recorder with editing capability . . . . List: $495.

JUSTIFICATION: A VCR with tuner is essential to interface with cable distribution systems. This model is an editing recorder which will allow students to videotape transmissions from elsewhere for future use.

4) Crown D-75 Amplifier . . . . List: $549.

JUSTIFICATION: This high quality sound amplifier is essential for producing video sound or room public address amplification as desired. The unit has sufficient power for a larger room if a future change is made.

5) Two speakers, JBL Control - 1+ . . . . List: $395.

JUSTIFICATION: These speakers for the room sound system are compact and unobtrusive, yet can accommodate additional amplification required for a larger room if future plans include relocation.

6) Case . . . . List: $450.

JUSTIFICATION: This is the equipment cabinet which would be positioned in a corner of the room. The case will accommodate VCR, switcher-distribution amplifier, audio mixer, sound amplifier, power control and colorbar generator.

7) Screen .... List: $200.

JUSTIFICATION: This screen is a 70" model and is retractable. This item is easily relocated as well.

8) Miscellaneous cabling, connecters and other installation hardware .... List: $500.

JUSTIFICATION: This is the accompanying hardware necessary for installation and interconnection of all electronic equipment for the room.

9) Colorbar Generator - Sigma TSG440 .... List: $1,900.

JUSTIFICATION: The colorbar transmitter, with superimposed character generated logo, is designed to feed continuous audio and video signals. This addition will allow technicians to monitor the signal at all times.

10) Audio/Video Distribution Amplifier, Panasonic AG-DA100 .... List: $880.

JUSTIFICATION: This item is essential as both an audio and video source switcher. In addition to providing necessary routing functions, the amplifier allows Independence personnel to switch video sources between the classroom camera and the colorbar generator, as well as audio sources between classroom sound and test tone signal.

11) Power Conditioners(Line) - Two .... List: $400.

JUSTIFICATION: Power conditioners are essential to help regulate power distribution and compensate for power surges. One unit runs continuously to accommodate the colorbar generator. The other regulates all other electronic equipment.

12) Required Miscellaneous Equipment:

Custom Built Teaching Console	$ 2,500.
Instructor LCD 5" TV Monitors(2)	1,200.
Motorized Camera Control and Zoom Lens	1,100.
Rollabout Videoconference Console (with camera, TV monitors & speakers)	22,000.
Instructor's Camera (3-chip)	5,000.
Instructor's Remote Control Panel	3,500.
Extra Modeling Lighting	500.
Echo Canceler	4,900.
Stereo Return Monitor (31")	1,500.
TOTAL COST -	**$72,004.**

PROFESSIONAL DS-3 DISTANCE EDUCATION CLASSROOM EQUIPMENT- OPTION 3

I. Video System

Qty	Model	Description	Unit Price	TOTAL
3	DXC930	Sony Compact 3 CCD 1/2" Camera	$5,275.	$15,825.
3	PH15X7BKTS	Canon 15:1 Teleconferencing Zoom Lens	2,720.	8,160.
3	CCUM3	Sony Camera Control Unit for DXC930	1,735.	5,205.
3	CMA8A	Sony AC Adaptor for CCUM3	615.	1,845.
3	RMM1800	Sony Rack Mount Kit for CCUM3	170.	510.
3	CCQ50AM	Sony 50 M CCU Cable	625.	1,875.
3	CCTQ3RGB	Sony Adaptor Cable for DXC930	250.	750.
3	V6135BPT	Vicon Pan & Tilt	1,995.	5,985.
3	V6616WM	Vicon Wall Mount	140.	420.
1	SVO1410	Sony VHS Recorder		500.
1	RKSVOP10	Sony Rack Kit for SVO1410		80.
1	VP9000	Sony U-Matic SP Player		2,980.
1	F8521	Winsted Rack Kit for Sony VP9000		260.
1	EV368	Elmo Electronic Overhead Projector		3,850.
1	PVM8040	Sony 8" Color Monitor		760.
2	PFR	Grass Valley Video Audio Switcher/Serial	1,285.	2,570.
1	VPH1271Q	Sony Color Video Projector		19,990.
1	PBM1270	Progressive Marketing Ceiling Mount		300.
1	PMM10	Progressive Marketing Extension Column		325.
1	40747	Dalite 8'X10' Matte White Boardroom Electrol Screen		1,718.
1	40973	Dalite Low Voltage Control Option		277.
SUBTOTAL				**$74,185.**

Qty	Model	Description	Unit Price	TOTAL
II. Audio System				
1	ST6300	Shure Type 2 Video-Conference Mixer		$ 7,130.
2	ST6008	Shure 8 Input Expansion Mixer	4,000.	8,000.
18	STM30W	Shure Teleconferencing Microphone (Black)	170.	3,060.
1	LS114/84	Shure Wireless Microphone System -Complete system including body pack transmitter, Diversity receiver and WL84 Lavalier Microphone *MIC Configuration and numbers will vary depending on the layout of the classroom.		620.
1	M267	Shure MIC/Line Mixer		535.
1	A268R	Shure Rack Mount Kit for M267		28.
1	GQX3101	Ashly Single Channel 31 Band Equalizer -for Video Sources		659.
1	D75	Crown Audio Amplifier		549.
2	WSA70	RAMSA Speaker	280.	560.
1	WSAQ1W	RAMSA Wall Mount Brackets (pr)		170.
1	A903A	TOA 6 Input Mixer/30 Watt Amplifier		480.
2	UO1S	TOA Line Input Module	36.	72.
1	GQX3101	Ashly Single Channel 31 Band Equalizer -for Microphone Audio		659.
10	C10T70	Soundolier Speaker w/70 Volt Transformer	27.	270.
10	Q408	Atlas Round Recessed Back Box	73.	730.
10	628	Atlas Recessed Steel Trim Ring Baffle	11.	110.
10	758E2	Atlas 8" Mounting Ring Ceiling	10.	100.
SUBTOTAL				**$23,732.**

CONTROL SYSTEM

Qty	Model	Description	Unit Price	TOTAL
III. Control System				
1	AMXCTL	AMX Control System		$ 18,900.
		NON-EQUIPMENT COSTS		
1		Engineering/Design Services		1,620.
1		CAD Services		1,425.
1		Installation Parts		1,360.
1		Installation Labor		2,550.
1		System Service Checkout		1,550.
SUBTOTAL				**8,505.**
TOTAL PROFESSIONAL SYSTEM				**$125,322.**

SAMPLE MULTIPOINT CONTROLLER COSTS - T1 SYSTEM

Proposed Configuration - Purchase

	Price
MULTIPOINT CONTROL UNIT	
Base Unit	$75,000.
Options	
Add'l Site Interface Sub-assembly	$ 8,000.
Add'l Communication Interface	1,000.
Audio Only Participant	2,500.
Accessories	
14-Site Conference Control Unit	$ 1,000.
Rack Mounting	150.
Net Purchase Price	$87,650.
Installation	$ 1,500.
Training	$ 1,000.
TOTAL	$90,150.

DS-3 OPTION CODEC EQUIPMENT

I. Video System

Qty	Model	Description	Unit Price
1	Grass Valley "E"	Fully Configured DS-3 codec with 4 DS-1	$19,000.

IX. DS-3 AND BROADCAST FM/TV REQUIREMENTS

1. It is the intent of WECB to utilize vendors and transportation topology which will give the WECB increased flexibility to easily and cost-effectively incorporate technology advances as they occur.

2. In general, the requirement is to lease the entire channel capacity of each microwave channel, each digital fiber channel, or satellite transponder (or portion of satellite transponder as appropriate). Contractor will supply new cards, compression equipment, and other compatible add-ons, at a pre-determined cost, at Owners' request during the life of the contract. The pre-determined cost(s) will be based on the Contractors' cost override requirements for these services, ie. (percentage cost to WECB over and above Contractors actual cost of hardware, software and installation). It is the intention of WECB to pre-define the costs of wider bandwidth and/or additional channels during which may be required during the contract period. These cost definitions may be in terms of costing parameters the values of which may be unambiguously determined at the time additional capacity will be required. For instance, when the FCC finalizes HDTV standards, higher capacity transportation will be required to the TV stations. With pre-defined cost factors, the WECB can determine when HDTV capacity can be added to each route based upon affordability.

3) Radio Bandwidth/Modulation Requirements

   a) FM/AM Talk radio requirements:

      1) Two 19 KHz bandwidth channels

      2) Analog = 500/F3
      OR
      3) Digital = 256 Kbs

   b) FM Music radio requirements:

      1) Two - 19 KHz bandwidth channels

      2) Analog = 500/F3
      OR
      3) Digital = 256 Kbs

   c) FM Radio SCA requirements:

      1) One 7.5 KHz or 64 Kbs Bandwidth channel

4) Radio Technical Standards

   The following technical standards are required:

   a) Reliability for transmission paths:

      1) Analog = 99.9995%

      2)- Digital = BER [1 X 10^{-11}]

5) Radio Transmission Standards

The network transmission standards will meet or exceed the following Rules & specifications:

a) Part 73.682 and 73.317 of FCC Rules

b) The EIA RS-250C standards (short, medium and long haul)

c) The NAB Standards as contained in the **NAB Engineering Handbook** Eighth Edition, Chapters 1.4, 1.7, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 6.3, 6.4, 7.1, 7.2, 7.3, and 7.4.

d) National Public Radio (NPR) as apply.

6. Television Bandwidth/Modulation Requirements

The following bandwidths may be supplied for transport of the Television signal. Analog bandwidths may depend upon microwave frequencies in used.

a) Analog = 25000/F9

b) Analog = 20000/F9

c) Analog = 18000/F9

d) Digital = 45 Mbs (["high-cap"] DS3)

7. Television Technical Standards

The following technical standards are required:

a) Reliability for transmission paths:

Analog = 99.9995%

Digital = BER 10-11

8. Television Transmission Standards

a) The network transmission standards will meet or exceed the following Rules & specifications:

1) Part 73.682 and 73.317 of FCC Rules

b) The EIA RS-250C standards (short, medium and long haul)

c) The NAB Standards as contained in the **NAB Engineering Handbook** Eighth Edition, Chapters 1.4, 1.7, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 6.3, 6.4, 7.1, 7.2, 7.3, and 7.4.

d) Public Broadcasting Service as applies.

c) Final Test and Acceptance

9) The Final Test procedure shall consist of the following minimal measurements:

a) Audio Requirements

1) Frequency Response

A frequency analysis shall be conducted using a FCC type accepted precision attenuater and a signal level monitor, or an audio spectrum analyzer and sweep generator with a resolution of 1 Hz and 1 dB. Individual measurements shall be made at least 20 Hz, 50 Hz, 100 Hz, 200 Hz, 500 Hz, 1 KHz, 2 KHz, 5 KHz, 7.5 KHz, 10 KHz, and 19 KHz. Swept measurements shall be made continuously from 20 Hz to 20 KHz. Across the appropriate bandwidth, the frequency response shall not vary by more than +/- 1.5 dB:

a) 20 Hz to 19 KHz for 19 KHz audio

b) 20 Hz to 7.5 KHz for 7.5 KHz audio

2) Harmonic Distortion

Harmonic distortion shall be tested at the same frequencies indicated in a) above. THD shall be calculated using the following formula:

$$THD\% = \{100 \surd(A_2^2 + A_3^2 + A_4^2 \ldots A_N^2\}/A^1$$

Where A_1 is the fundamental voltage amplitude across the appropriate terminating impedance, while A_2 - A_N are harmonic frequency voltage levels, mmeasurements may be made using either an FCC type accepted distortion analyzer or an appropriate spectrum analyzer. THD shall be below 2% on all frequencies.

3) Intermodulation distortion shall be measured using an FCC-approved test set and the SMPTE method (60 Hz and 7 KHz tones). Intermodulation so measured shall be less than 1%.

4) Noise measurements shall be conducted by employing the full bandwidth of 19 KHz or 7.5 KHz as appropriate. CCIR/ARM weighting shall be used, and the total noise shall be greater than -60 dB or greater with respect to the voltage signal level representing 100% transmitter modulation.

5) Stereo measurements (differential phase and gain or crosstalk) shall be measured using the NAB test CDI and CDII, along with an approved audio generator and an oscilloscope. Differential phase or the two channels shall be 1° or less, differential gain shall be 1.5 dB or less, and crosstalk shall be -60 dB or better.

10. Television Requirements

At a minimum, the following tests will be conducted in order to approve signal coverage of TV signals:

a) Multi-burst Frequency Test
The white flag pulse is to be set to 1.0 volt from sync peak to pulse peak. Six sine wave bursts at 0.5, 1.5, 2.0, 3.0, 3.6 and 4.2 MHz will be utilized. All bursts should be within 2% of the one volt reference with an FCC approved waveform monitor set to 62 microseconds.

b) Two-field Window Signal
Tilt should be checked on an FCC type approved waveform monitor and should be less than 1%. Ringing

amplitude should be less than 2%, and low frequency hum should be less than 0.5%.

c) Pulse and Bar Test
Both T and 2T pulse ringing tests will be performed. All ringing will be less than 1%.

d) Differential Gain Test
Differential gain will be measured by employing a stair step signal. System linearity shall be checked by employing the stair step with no modulation differential gain shall employ 3.58 MHz subcarrier modulation of the stair step signal. Linearity shall be within 2% from step to step, and differential gain shall be better than 2% at 10% APL, 50% APL, and 90% APL.

e) Differential Phase Test
Differential phase measurements should employ the same procedure indicated in d) above, and a Textronix 520 or equal as a phase comparator. Differential phase shall be less than 0.5° at 10% APL, 50% APL, and 90% APL.

f) Video signal-to-noise shall be measured employing an EIA filter and hum reject filter. This value shall be better than -60 dB below peak signal.

g) Video signal-to-hum shall be made using an oscilloscope in place of the waveform monitor and a hum filter. This value shall be better than -50 dB below peak level.

h) Color bars - Color tests shall be within limits defined on the vectorscope.

i) Other tests may be ordered by WECB, including but not limited to sine pulse, test pattern, etc.

j) Measurements on the television audio channel will be made in the same manner as above.

11. Network Support Requirements

a) Network Management

1) Monitoring and remote control

Proposer will include provisions to allow WECB to monitor relevant transmission parameters at the endpoints of all paths from the TOC in Madison. Two-way remote control telemetry will be supported at 56 Kbs. Proposers should provide details of NAP port provisions, as well as software and hardware required to run the network management program available to WECB. All network functions will be password protected.

b) Network Security

1) The Proposer shall describe methods by which the signals carried will be secure from interception, tampering or other forms of interference or vandalism. The proposer shall also describe the physical security employed at terminal sites, as may apply.

2) Proposers shall submit a plan for alternate network signal routing in the event of a catastrophic failure of **any single system component.** A complete "hot-stand-by" system may be bid, but alternate bids specifying 8 hour restoral times for system transceiving equipment (such as transmitters and receivers). 24 hour service restoral times involving the loss of a major system components (such as a tower or an antenna) must also be included.

12. Maintenance/Service of the Network re: Demarcs

a) All Maintenance of network microwave or fiber optic equipment on the Contractor side of the DEMARC will be performed by the Contractor during the Lease period.

1) The Owner side of the DEMARC shall be at the output of the microwave receiver if an Owner STL is used, or the input of the fiber optic or coaxial terminal equipment that is located on, or within the Owners' premises.

2) If the Contractor supplies CODECS for digital modes of transmission; the Contractor shall maintain the Codecs. In this event, the Codecs shall be ABL VT-45A or equal.

REQUIRED PERFORMANCE TEST

All Channels Demodulated Video

Video Performance	Signal	Standard	Measurement
Frequency Response	60 IRE Multiburst	0 IRE	
Chroma/Luminance Gain	NTC-7 Composite	0 IRE	
Chroma/Luminance Delay	NTC-7 Composite	0 NS	
Differential Gain	NTC-7 Composite	1%	
Differential Delay	NTC-7 Composite	1°	
Line			
Field Time Distortion	100 IRE Window	0	
Signal to Noise	10 KHz to 5.0 MHz	61 dB	
Signal to Hum	0 to 10 KHz	64 dB	
Front Panel Meter AGC #1			

Audio Performance	Signal	Standard	Measurement
Program Level	1 KHz	+8 In	
Frequency Response	Reference Levels	-16 dBm	
	40 Hz	+.3	
	100 Hz	0	
	1 KHz (ref Freq.)	0	
	5 KHz	0	
	7.5 KHz	-.1	
	10 KHz	-.3	
	15 KHz	+.7	
Total Harmonic Dist	40 Hz, +4 dBm	.09%	
	100 Hz, +4 dBm	.15%	
	1 KHz, +4 dBm	.28%	
	5 KHz, +4 dBm	.48%	
	7.5 KHz, -6 dBm	.09%	
	10 KHz, -6 dBm	.08%	
	15 KHz, -6 dBm	.17%	
Signal to Noise		74 dB	

DISTANCE EDUCATION

GLOSSARY OF TERMS

The following represents terms which are often used in discussions on Distance Learning (or the synonymous Distance Education). Definitions for the terms are provided; where appropriate, the definitions are given in the context of the WECB system:

A, B, C, D, G CHANNEL GROUPS: ITFS channels are designated in groups of four frequencies designated by these letters of the alphabet and a number, e.g., A-1, A-2, A-3, A-4

ACCESS CHARGE: A charge paid to a local telephone company for the availability and use of exchange facilities for origination and termination of inter-exchange services

ACTUATOR: The drive system attached to the antenna mount that automatically aims the antenna at each satellite

AD HOC TELECONFERENCE: Refers to a teleconference that uses facilities that link together for a specific event

ADM: Add-Drop Multiplexer - A piece of equipment which allows dynamic software-controlled configuration of circuits in a digital switched network. An ADM is specific to the SONET environment and functions much like a "Northern Telcom 445" in a nonSONET environment.

AGC: Automatic Gain Control

AI: Artificial Intelligence - A computer system capable of "intelligent" action

ALA: American Library Association

ALGORITHM: In audio and video coding, the step-by-step procedure (often including repetition) that provides suitable compression for the specific application. This mathematical process results in a significant reduction in the number of bits required for transmission and may be either lossless or lossy

ALSS: Adult Learning Satellite Service

AM: Amplitude Modulation - Encoding a carrier wave by variation of its amplitude

AMPLIFIER: An electrical device used to strengthen audio or video signals or radio frequency (RF) energy

ANALOG/DIGITAL: Two opposite kinds of communications signals. In analog, information is transmitted by means of modulations of a continuous signal, such as a radio wave. Digital is based on a binary code in which the picture or audio information is sent as a series of "on" and "off" signals; it is more precise and less subject to interference than analog.

ANTENNA: A structure used to receive or transmit radio or television signals, i.e. a satellite dish

ASCII: American Standard Code for Information Interchange - Common code for alphanumeric characters; this code enables communication among different computer systems

ASPECT RATIO: The rectangular dimension of visuals used in television, 3 units of height to 4 units of width

ASYNCHRONOUS/ASYNCHRONICITY: "Time-independent" -- the capability of a communications technology to store and record programming for later playback (e.g. VCR's, microcomputers), making scheduling less crucial

ATTENUATION: The loss in power of electromagnetic signals between transmission and reception points

AUDIO: Sound energy which codes information understandably to a human listener

AUDIO CONFERENCE: A telephone conference call using special equipment to maintain the strength of the signal among all parties

AUDIOGRAPHICS: The simultaneous transmission of voice and computer graphics over ordinary phone lines. This allows voice and graphics interaction among participants. Graphics may be drawn with a variety of utilities: sketch pad, mouse, scanned in, or video camera. It can be created ahead of time and stored like a slide show or transferred from CAD. It allows for a high degree of action, since several sites may interact at one time.

AUDIOTEX: A database-access system in which users employ touch-tone telephones to access electronically stored and delivered libraries of short audio messages

AUDIO SUBCARRIER: The carrier wave that transmits audio information between 5 and 8.5 MHz on a satellite broadcast

AZIMUTH: Angle in degrees left or right of true north between antenna beam and meridian plan (measured in horizontal plane)

BANDWIDTH: The amount of the electromagnetic spectrum that a given signal occupies. Usually expressed in Kilohertz (thousands of Hertz, or KHz) or Megahertz (millions of hertz, or MHz)

BAUD RATE: The speed at which data is communicated (approximately equal to bits per second); most commonly 300, 1200 and 2400 baud for ASCII computer messaging services

BEAMWIDTH: The acceptance angle of an antenna, usually measured between half-power (3 dB) points

BELL SYSTEM: A group of affiliated RBOCs (Regional Bell Operating Companies) in the United States that operates under consistent rules and specifications, many of which are set by AT&T

BER: BIT Error Rate - The fraction of a sequence of message bits that are in error. A bit error rate of 10^{6} means that there is an average of one error per million bits

B-ISDN: Broadband Integrated Services Digital Network - A digital signalling network in which equipment interface data rates operate at speeds of 155 to 622 million bits per second (MBs)

BIRD: Slang for communications satellite

BIT: Binary Digit - A bit is the smallest unit of information used by a computer represented by a "1" or "0," or by "on" or "off"

BITM: Bureau of Information and Telecommunications Management, Wisconsin Department of Administration

BITNET: An international academic research electronic mail and file transfer network linking over 1300 university and college computing centers in 21 countries

BLOCK DOWNCONVERTING: The multi-conversion process of converting the entire band to an intermediate frequency (4 GHz to 1 GHz) for transmission to multiple receivers, where the next conversion takes place

BNC: A type of bayonet-lock coaxial cable connector used for video and communications

BRIDGE: A device which connects 3 or more telecommunications channels, such as telephone lines

BROADBAND: Broadband channels have enough bandwidth to carry full motion video, stills, graphics, audio and text (e.g., fiber optics, cable television, ITFS)

BROADCAST: Television and radio designed to reach mass audiences with an audio or video signal that is transmitted from a central point and can be reached by persons around the transmitter using standard radio or television receive equipment

BYTE: A group of bits, usually eight, handled as a unit by a computer operating system

CAD: Computer Assisted Design - Computer drawing software that allows user to create visual representations in color, according to scale, and in multiple dimensions. While software is applicable to a number of content areas, it offers exceptional promise in vocational education for learning automotive, drafting, electrical, landscape, and interior design

CAI: Computer Assisted Instruction

CAM: Computer Assisted Manufacturing

CAMERA: The instrument which converts a visual image into electrical impulses

CARRIER: 1) A provider of transmission capabilities available to the general public, sometimes referred to as a "common carrier" or "regulated carrier", as it is regulated by the FCC. 2) A current in a communications channel which can be modulated to carry analog or digital signals. 3) A telephone company or similar non-private telecommunications service supplier (telecommunications usage). 4) The radio frequency wave that is modulated by the baseband information signal.

CARS: Cable TV relay service

CATV: Community Antenna Television - A master antenna and distribution system capable of receiving, amplifying and distributing a television signal via coaxial cable to television receivers. Also known as Cable Television end user.

C-BAND SATELLITE TELEVISION: Channels from 4 to 6 gigahertz used mainly to transmit and receive signals to and from communication satellites. Satellites operating in the C-Band transmit the majority of video programming for broadcast and cable use as well as telephone transmissions and other data. (Used loosely for satellite services in the 6/4 GHz bands.

CCITT: Consultative Committee of the International Telephone and Telegraph Group. This committee is working to produce the "PX64" standard for compressed video equipment, so that codecs of various manufacturers can be used together.

CCTV: Closed Circuit Television - A TV system in which the transmission of the TV signal is limited to only those receivers that are physically connected to the system

CCS-7: Common Channel Signaling Number 7, a method of communication between digital switches, including database access among switches. Among its uses are monitoring of and accounting for networks. Standards for CCS-7 are part of OSI.

CD-I: Computer Disc Interactive

CD-ROM: A storage technology which can be used to keep information which can be read by a computer or similar hi-tech device. Uses the same technology as audio Compact Discs and movie Video Discs.

CD-V: Computer Disc Video

CELLULAR RADIO: A mobile telephone technology that improves on existing mobile phone systems by dividing a metropolitan area into a number of smaller areas or cells, each served by a small low power transmitting and receiving station. A car traveling from one cell to another is automatically switched onto that cell's particular frequency, allowing for continuous en route phone conversations or data communications. Each transmitting station is connected to a mobile phone switching office and the local telephone switching center.

CENTRAL SANDS: Central Sands Telecommunications Consortium, an ITFS user group comprised of university, K-12 schools, and potential private institutions in the Stevens Point area

CENTREX: A widespread telephone company switching service that uses central office switching equipment to which customers connect via individual extension access lines

CES: Cooperative Extension Service, UW-Extension

CESA: Cooperative Educational Service Agency

CHANNEL: A band of frequencies allocated for communications

CHANNEL BANDS FOR TELEVISION:
Low band - VHF Channels 2 through 6
Mid band - Cable Channels 14 through 22
High band - Cable Channels 7 through 13
Super band - Cable Channels 23 through 36
Hyper band - Cable Channels 37 through 59
UHF - Received on broadcast television Channels 14 through 83

CHANNEL BANK: A piece of equipment which allows typically 24 analog circuits to be sampled and converted into digital signals having 64,000 bits/sec per channel and subsequently merged into a time-divided bit (i.e. DS-1) formal at a rate of 1.544 MBs for transmission on a single T-1 facility between two points. Channel banks or digital multiplexers are required at both ends of each link to combine (at one end) and separate (at the other end) the component signals. Using channel banks, slow-scan TV, data and phone signals can be sent on the same T-1 link.

CITSC: CESA Instructional Technologies Services Council

COAX, COAXIAL CABLE: The copper-wire cable that carries audio and video signals and radio frequency (RF) energy, consisting of an outer conductor concentric and inner conductor, separated from each other by insulating material. It can carry a much higher bandwidth than a wire pair.

CODEC: COder/DECoder - Digital encoding/decoding equipment that is necessary to interface analog end-user equipment (such as a television set) to digital transmission facilities. In the case of compressed video, codecs are also used to restore some of the motion which is taken out in the compression process.

COMMON CARRIER: A telecommunications company that holds itself out to the public for hire to provide communication transmission services. Your local telephone company is an example of a common carrier.

COMMUNICATIONS SATELLITE: A satellite in earth orbit which receives signals from an earth station and retransmits the signal to other earth stations

COMPOSITE VIDEO SIGNAL: A video signal incorporating luminance, color and synchronizing information

COMPRESSED VIDEO: With compressed video, instead of transmitting a series of full-motion video frames, only the changes in moving frames are captured and transmitted. The reconstituted image exhibits some motion, but, depending on the available bandwidth and the capacity of the transmitters and receivers, motion may appear somewhat irregular. This effect occurs because in compressed video technology the moving areas of the image are only approximated.

COMPUTER MESSAGING SYSTEMS: Include electronic mail, bulletin boards and computer conferencing. Messaging systems involve the exchange of information between computers using telephones or other telecommunication lines and a central "host" computer that stores the messages.

COMPUTER CONFERENCING: An interactive conferencing system that allows specific groups of users to enter papers, texts or comments. Participants can reach the conferencing system with microcomputers or terminals at any time, read the materials that have been submitted by other participants since the last session, and submit their own comments.

CONFERENCE CALL: A call in which ordinary telephone lines from a number of locations are linked together through the assistance of a telephone company or telephone bridge

CONNECTIVITY: The ability of devices to exchange data with each other through shared connections locally or at a distance

CONSORTIUM: A voluntary organization loosely affiliated for a specific purpose

CONUS: Contiguous United States

CP: Construction Permit

CPB: Corporation for Public Broadcasting

CPE: Customer Premises Equipment - Telephone equipment, such as phones and private branch exchanges (PBXs), located on the customers premises

CPU: Central Processing Unit of a computer

CROSSTALK: 1) The unwanted energy transferred from one circuit, called the disturbing circuitry, to another circuit called the disturbed circuit. 2) Undesired power coupled into a communications circuit. Telephone crosstalk may be either intelligible or unintelligible.

CRT: Cathode Ray Tube

CSG: Community Service Grant

C-SPAN: Cable-Satellite Public Affairs Network

C/T: Carrier-to-Noise-Temperature ratio. Ratio of received carrier power level to noise level of a satellite antenna, measured in decibels.

CTN: CESA Teleconference Network - A four-wire dedicated telephone system operated by a CESA. CESAs 3, 8 and 12 have CTN systems. CTN systems can be interconnected with ETN.

CWETN: Central Wisconsin Educational Telecommunications Network - A consortium of schools located near Spencer, using an interactive television network

DAC or DCS: Digital Cross-connect Switch - A remote device (controlled by a central site switch) which can route data, voice, or video signals to a specific destination. A simplified example: suppose phone lines from City A, City B, and City C go to a local DAC and then one line goes from the DAC to the central switch site at City D. A call from City D to City A will be made by the DAC switching the call to the City A circuit. A call from City B to City C will be switched through the DAC and will not use the line to City D (the central switch). The advantage of the DAC is that separate phone circuits are not required from each city to the central switch site; also, this setup prevents every single call from going through the central switch site, thereby relieving traffic.

DATABASE: Information storage system which can be searched through a number of methods to obtain specific data. The term "database" has been in the past associated with computer services, but is now used to refer to general information storage and retrieval systems (e.g. audiotex, teletext, etc.).

DATA PORT: The physical and electrical protocol used by the codec and the DSU or TA to transfer data between each other. A codec comes with either V.35 or X.21 protocol built in. These are actually the number of CCITT international standards which specify pinning, levels, etc. V.35 is very common for networks in North America, and X.21 is popular on European-manufactured ISDN terminal adapters.

DATA RATE: Analog transmission media is specified in bandwidth (usually in Hertz) and signal to noise (usually in dB). Since the principles behind digital transmission are so different, media are specified in different parameters. Rather than how much analog information is passed, a digital user is concerned with how many bits per second can be sent down the channel.

DATCP: Department of Agriculture, Trade and Consumer Protection

dB: Decibel - A means of expressing ratios logarithmically. (Number of dB 10 x log (base 10) of power ratio. So, 3 dB represents a factor of 2, 10 dB a factor of 10, 20 dB factor of 100, etc. If an antenna has 3 dB gain over another, then it would be twice as powerful.) The standard unit of difference of levels to permit measurement of power, voltage, or current levels in electric or electronic practices

dBI: dB power relative to an isotropic source

DBS: Direct Broadcast Satellite - Multiple satellite entertainment and information services received via TVRO system on a subscription basis

dBW: The ratio of the power to one Watt expressed in decibels

DCAIN: Dane County Area ITFS Network - An ITFS user group in the Madison area

DDS: Digital Data System - This is the most common point-to-point, dedicated digital telephone service which works well with the codec. The user pays a monthly charge to the phone company for a full time link, no matter how much he actually uses it.

DDS: Direct Digital System - A network whose component parts and signals (representing information of various types) are all transmitted via standardized digital signalling methods. In a DDS network, no analog-to-digital converters are necessary.

DECLINATION: Angle between antenna beam and equatorial plan (measured in meridian plane). The offset angle of an antenna from its polar mount axis.

DECODER: A device used to unscramble purposely scrambled television signals

DEDICATED CHANNELS: Channels that are reserved for specific uses. Government, education and public access cable channels are examples of dedicated channels.

DEDICATED LINES: A leased or purchased line that connects two or more data communication sites used exclusively by one vendor or user

DEMARC: Demarcation - The location(s) where customer-provided equipment is connected to carrier-provided equipment. Example: the splice block where a telephone line enters most homes is a demarc; everything on the line side of the demarc is the responsibility of the telephone company, while everything on the home side (i.e. the house wiring and the telephones themselves) is the responsibility of the homeowner. The WECB demarcs refer to locations where access to the backbone network is made available.

DEMODULATION: The process of retrieving an original signal from a modulated carrier wave

DESCRAMBLER: An electronic device that decodes encrypted satellite signals

DETIC: Distance Education Technology Initiative Committee

DHSS: Wisconsin Department of Health and Social Services

DIGITAL SIGNALS: Digital technology converts audio, video and data into a series of "off" and "on" signals. Digital channels are generally more precise, less subject to interference, can carry more information and can support higher transmission speeds than analog systems.

DIGITAL VS. ANALOG: An analog electrical signal (sound or light, etc.) is noted by a fundamental change in character with respect to the information being conveyed. For example, an AM radio station changes the amplitude of a carrier signal to varying degrees depending on the amplitude of the music it is carrying. A digital signal is always in one of two states (on or off), but varying at a rate fast enough that information encoded into numbers (quantized) can be transferred. Another way to look at the difference is that an analog signal has an infinite number of degrees of changes which convey information. A digital signal has only two. One of the largest advantages of digital transmission is that as long as a receiver can distinguish between the two states in the signal, noise will have no effect on it.

DILHR: Wisconsin Department of Industry, Labor and Human Relations

DIN: Decision Item Narrative - An individual descriptive proposal in the budget preparation process

DISH: Slang for satellite earth station antenna

DISTANCE EDUCATION: Instruction that takes place in a setting where the teacher is in contact with the student by means of correspondence or telecommunication technologies. These technologies are often used to link student and teachers within or between districts and states, as well as internationally. These technologies include broadcast and narrowcast radio and television (e.g., cable, fiber optics, ITFS, microwave, satellite, etc.) telephone, video disk, video tape, and computer applications.

DMA: Wisconsin Department of Military Affairs

DMA: Designated Market Area

DMS-100: The model number for a large central office switch made by Northern Telecommunications. The DMS-100 has the capability to switch other types of lines in addition to telephone lines, such as T1 circuits.

DNR: Wisconsin Department of Natural Resources

DOA: Wisconsin Department of Administration

DOC: Wisconsin Department of Corrections

DOJ: Wisconsin Department of Justice

DOR: Wisconsin Department of Revenue

DOT: Wisconsin Department of Transportation

DOWNCONVERSION: Translation of frequency or a block of frequencies to a lower portion of the electromagnetic spectrum, e.g., from SHF (microwave) frequencies to UHF and VHF.

DOWNCONVERTER: A device used to lower the frequency of any signal

DOWNLINK: A satellite receive system that processes satellite delivered information, and includes the satellite itself, the receiving earth station and the signal transmitted downward between the two. Occasionally, this word is used to refer to the TVRO dish itself.

DOWNLOADING: The process involves transferring information from one device to another over a telecommunications channel (e.g. telephone, broadcast). Information received from the originating source can then be stored by the receiver for future use.

DPI: Wisconsin Department of Public Instruction

DS-0/DS-3: Designations given to circuits of different bit rates. A DS-0 circuit has a bit rate of 56 KBs (actually, the full width is 64 KBs, but the rest is used for overhead associated with the transfer). A single digital telephone circuit uses a DS-0. A DS-3 has a bit rate capability of 45 MBs, which is equivalent to 28 T1 circuits, or 672 DS-0 circuits.

DS-1: See T-1

DSP: Digital Signal Processing - The concept of sampling analog waveforms in discrete time and manipulating these samples using algorithms which would be difficult or impossible in the analog domain

DSU/CSU: Data Service Unit/Channel Service Unit - On some data networks, these are two separate devices. On most networks used with the codec, this is a box which sits between the codec and the data circuit, used to interface and condition the data coming on and off the network. This box may also contain diagnostic testing functions and indicators, and in the case of switched services, will perform all your dialing functions. A DSU/CSU is required for all SW56 and DDS circuits, and is not included with your codec

DTE/DCE: Data Terminal Equipment/Data Computer Equipment - To avoid confusion, the data protocols mentioned above designate equipment and ports as either DTA or DCE. In the case of the codec, the DSU/CSU or TA is ALWAYS the DCE and the codec is ALWAYS the DTE. Plugging two DTEs together will not establish communication between them, since the DCE provides all the clocks required to run the data around.

DUPLEX: On the plain old telephone system (POTS), the audio transmission can be considered "half duplex" since if both parties speak at the same time, their voices will intercept on the single pair of wires on each end of the call. Most digital systems are duplex or "4 wire", allowing simultaneous and independent data (or encoded audio) to pass in each direction. Some systems may be "simplex" which pass digits only in one direction.

DVA: Wisconsin Department of Veterans Affairs

DYNAMIC ALLOCATION: The ability to add or remove resources to/from a system based on actual need. The alternative to dynamic allocation is to have a fixed amount of resources for a system, which are always dedicated to that system regardless of whether they are being used.

E-MAIL: Electronic Mail - Networking systems that allow users to send and receive messages via computers and telephone modems. Communication may be from within a building to international.

EARTH STATION: Equipment on the earth that can transmit or receive satellite communications. In general usage, this term refers to receive-only stations.

EBBs: Electronic Bulletin Boards - These are systems in which users can read and post short public messages or announcements stored on a central computer. Messages are sent and received by users with microcomputers equipped with modems and communications software; the messages may be screened and posted within categories established by the system operator.

ECB: Wisconsin Educational Communications Board - A state agency charged with developing, operating and maintaining educational telecommunications in Wisconsin. Services include Wisconsin Public Radio, Wisconsin Public Television, ITFS systems, School Radio Service, Learning Link, and a satellite uplink. The ECB is governed by a board comprised of representatives from UW, VTAE, DPI, DOA, the Wisconsin State Legislature, various councils, and private citizens.

ECHO SUPPRESSION: The insertion of mild attenuation in an acoustic echo canceler transmit and/or receive on the line (codec) side of the AEC. This eliminates howling caused by excessive closed-loop gain and is useful to attenuate any residual echo signals.

EDUCATIONAL TELEVISION: The use of television for classroom instruction and classroom enrichment programming, as well as community and cultural programming.

EEPROM: Electrically Erasable Programmable Read-only Memory - A non-volatile, but electrically alterable, form of semiconductor storage. These devices are present in some codecs, permitting long-term storage of codec configuration, dialing and related information for easy recall by the user.

EIA: Electronic Industries Association - A standards organization specializing in the electrical and functional characteristics of interface equipment

EIRP: Effective (or equivalent) Isotropic Radiated Power - Combined result of transmitter (or transponder RF power, and transmitting antenna gain

EL/AZ: (El over AZ) An antenna mount providing independent steering in azimuth and elevation

ELECTRONIC BULLETIN BOARD: See EBBs

ELECTRONIC CLASSROOM: An instructional area which is characterized by the presence of two-way distance learning facilities such as receive video, 2-way audio, and possibly such advanced features as computer image reception/transmission, ability for sending/receiving data from a central site, etc. Sometimes also referred to as in-house educational video equipment such as VCR's.

ELECTRONIC MAIL: A system by which written messages are entered through a keyboard and distributed to individuals or groups subscribing to the service. Messages are generally stored on a computer and forwarded to recipients when they request messages through the use of data terminal or other keyboard device.

ELEVATION ANGLE: The vertical angle measured from the horizon up to a targeted satellite

ENCRYPTION/DECRYPTION: Special coding or scrambling of a communication signal for security purposes

ENG: Electronic News Gathering - A small format video unit often used by commercial news operations

ERVING: Embarrass River Valley Instructional Network Group - A consortium of seven Waupaca and Shawano County school districts using fiber optics for distance education

ETHERNET: Baseband protocol and technology developed by Xerox and widely supported by many manufacturers; a packet technology that operates at 10 Mbps over coaxial cable and allows terminals, concentrators, workstations, and hosts to communicate with each other.

ETN: Educational Telephone Network - A four-wire dedicated telephone instructional system operated by Instructional Communications Systems (ICS), University of Wisconsin Extension. CTNs, ETN and two-wire telephones can be interconnected at ICS in Madison.

FAA: Federal Aviation Administration

FACILITATOR: The individual responsible for the local component at a distance education site who may or may not be an expert in the subject matter

FAX: Facsimile Machine - Electronic technology that transmits documents, usually over telephone systems. Facsimile devices are commonly referred to as FAX, telecopies or datafax.

FCC: Federal Communications Commission - The federal agency responsible for regulating all use of the air waves for broadcast and electrical telecommunications purposes

f/D: Focal-length-to-Diameter ratio (of a reflector)

FEEDBACK: (a) Video - distortion of the picture caused when a video signal reenters the switcher and becomes overamplified; (b) Audio - unpleasant howl from the speaker caused when the sound inadvertently is fed into the microphone and overamplified

FEEDHORN: The focal point on an antenna (e.g. ITFS or satellite) that gathers the signal and sends it to the receive line

FEED SYSTEM: The small, widebeam antenna that illuminates (gathers signal from) the reflector in an antenna system (convention speaks of illumination, even in a receive-only application, as if the antenna were transmitting)

FIBER OPTICS: A method for transmission of information (voice, video, data). Light is modulated and transmitted over high purity, hair-thin fibers of glass. The bandwidth capacity of fiber optic cable is much greater than conventional cable or copper wire.

FIRMWARE: Data and/or program software for the codec stored in a non-volatile form in a semiconductor memory circuit. For codecs, the firmware is often housed in a plug-in module.

FIRST MILE CONNECTIONS: Refers to the way in which programming is delivered from its source to a transmitter

FM: Frequency Modulation - Encoding a carrier wave by variation of its frequency

FOCAL LENGTH: The distance from the reflective surface of a parabolic antenna to the point at which incoming satellite signals are focused; the focal point

FOCAL POINT: The point to which incoming satellite signals are focused from the reflective surface of a parabolic antenna

FOOTPRINT: Coverage area of a satellite beam; a contour map showing EIRP, RFD, antenna size, or G/T contours within a satellite's coverage zone. Different satellites have different footprints. Some footprints cover as much as one-third of the earth.

FOTS: Fiber Optics Transmission System - With little time delay, very low bit error rate, a superior method to transmit digital video signals

FOUR-WIRE TELEPHONE: Dedicated telephone system that uses four wires (two to send and two to receive) and requires special telephone equipment. ETN and CTNs use this technology for interactive classes and meetings that link users over a wide area.

FREQUENCY: The number of cycles per second of a electromagnetic transmission, usually described in hertz. Generally, high frequency transmissions can carry more information at greater speeds than low frequency transmissions.

FRESNEL ZONE: With respect to an antenna radiating electromagnetic waves, this term refers to the volume of space within which physical obstructions or changes in the media supporting propagation will have a significant long-range effect upon the radiation pattern, or on the signal strength at the receiver

FULL DUPLEX: The ability to transmit simultaneously in both directions. A transmission system, together with its associated equipment, capable of simultaneously transmitting and receiving signals, as opposed to simplex (unidirectional) or half-duplex (one direction at a time) systems.

GAIN: A measure of the amount of signal level amplification of output to input power expressed in decibels

GANNT CHART: Project management chart showing activities as a series of bar charts

GATEWAY: Used to describe a device that acts to connect two or more dissimilar networks and makes possible communication between/among them

Gbs: Giga-bits per second - Defines a rate multiple at which data/information may be transferred across a communications line. 1 Gbs equals 1,000,000,000 bits per second, or approximately 125 million characters per second (assuming 8 bits per character).

GEOSTATIONARY ORBIT: An orbit located 22,300 miles above the earth's equator. In this orbit, a communications satellite rotates around the earth at the same speed the earth rotates so that the satellite appears to remain stationary when viewed from earth

GEOSYNCHRONOUS: Satellite orbit having a period equal to that of the earth's rotation (need not imply geostationary)

GEN-LOCK: The synchronization of a piece of video equipment with an external video signal. In videoconferencing systems, all cameras should be gen-locked together.

GHz: Gigahertz - Unit of frequency equal to one billion Hertz or cycles per second

GRADES: Green and Rock Area Distance Education System - An ITFS user group in the Janesville area

GRAINY PICTURE: A poor picture condition usually the result of weak signal strength and a uniform distribution of noise appearing as spots or streaks throughout the picture

G/T: (G upon T) Gain-to-noise-Temperature ratio of a receiving system; its sensitivity "Figure of Merit"

H.261: CCITT codec recommendation regarding a video codec for A-V services at p x 64kb/s (p = any integer from 1 to 32). Motion compensation and field sub-sampling (loop filter) are implementations optional in the standard.

HALF DUPLEX: A circuit that permits communications in both directions, but not simultaneously

HALF-TRANSPONDER: A method of transmitting two TV signals through a single transponder, by reducing the deviation and power allocated to each. Half-transponder TV carriers each operate typically 4 dB to 7 dB below single-carrier saturation power.

HARD COPY: Information printed in permanent form

HARDWARE: Electronic equipment such as: computers, satellite dishes, cameras

HDTV: High Definition Television - An emerging TV technology which gives better picture quality than standard TV, and a wider screen. Most HDTV technologies are digital encoding.

HEADEND: The central transmission point for a CATV or MATV system from which programming is distributed to users

HERTZ: A unit of frequency equal to one cycle per second (cps). One kilohertz equals 1000 cps; one megahertz equals 1 million cps; one gigahertz equals 1 billion cps

HOP: One leg of a microwave relay system (see microwave)

HORIZON-TO-HORIZON MOUNT: A type of satellite dish mount that allows the dish to track the arc of satellites from east to west

HUB: A point or piece of equipment where a branch of a multipoint network is connected. In a telegraph network, signals appear as dc pulses at the hub. A network may have a number of geographically distributed hubs or bridging points.

HYBRID SYSTEM: A system that combines two or more communication technologies

IBIT: Interim Board on Information Technology

IEEE: Institute of Electrical & Electronics Engineers

IFL: Inter-Facility Link - Anything from a cross-site transmission line to a complete data network

IHETS: Indiana Higher Education Telecommunications System

INTELSAT: International Telecommunication Satellite Organization

ISDN: Integrated Services Digital Network - The worldwide standard for digital telephony. The network signalling and transmission concept in which its wide area transmission is configured with equipment and transmission methods which utilize standardized digital signalling methods and equipment to enable voice, data, and video information to be transferred between user resources simultaneously.

ISO: International Standards Organization

IT: Information Technologies

ITAB: Information Technology Advisory Board

ITFS: Instructional Television Fixed Service - A technology which transmits television signals using frequencies higher than commercial television. This technology requires special licensing from the FCC and is available for use only by educational institutions.

ITV: Instructional Television

ITVA: International TV Association

IXC: Inter-Exchange Carrier - (As opposed to LEC) is a long distance supplier

JACK: A connecting device to which a wire(s) of a circuit may be attached and which is arranged for the insertion of a plug

JPEG: Joint Photographic Experts Group - An ISO video compression standard for storage and transmission of a variety of graphics images (not only NTSC in origin). It may be used in conjunction with fully compliant CCITT codecs and includes lossy and lossless modes.

K-12: Elementary, middle or high school (i.e. a school teaching one or more grades in the range Kindergarten through twelfth grades)

Ka-BAND: A satellite band (30/20 Ghz) used for spot beam experiments

Kbs: Kilobits Per Second - A rate at which data/information may be transferred across a communications line. 1 Kbs equals 1,000 bits per second, or approximately 125 characters per second (assuming 8 bits per character).

KHz: Kilohertz - Refers to a unit of frequency equal to 1,000 Hertz

KLYSTRON: High powered, very expensive tube used in TV transmitters

Ku-BAND SATELLITE TRANSMISSION: Refers to frequencies in the 11 to 14 GHz band. This band is used by the new generation of communication satellites to send and receive signals by satellite.

LAN: Local Area Network - A user-owned, user-operated, high-volume data transmission facility connecting a number of communicating devices (computers, terminals, word processors, printers, mass storage units, etc.) within a single building or campus of buildings

LASER: Light amplification by stimulated emission of radiation. This highly-focused beam of light (or its device) is used in fiber optics and optical video disc.

LAST MILE CONNECTIONS: The means by which programming is delivered to its final receiver (e.g. local ITFS system delivery of satellite-fed programming to home television sets)

LATA: Local Access Transport Area - Contiguous local exchange areas that include every point served by a Bell Operating Company within an existing community of interest and that serve as the dividing line for the allocation of assets and liabilities between AT&T and the Bell Operating Companies

LCD: Liquid Crystal Display - A very low-power device capable of displaying characters, words and symbols, often built into a codec or room controller panel

LEARNING LINK: A computer bulletin board utilized for educational related services

LEC: Local Exchange Carrier - A telephone company that provides local service (e.g. Wisconsin Bell)

LED: Light Emitting Diode

LINE OF SIGHT: Transmission path uninhibited by physical objects in the intervening terrain, ultimately limited by the curvature of the earth

LIP SYNC: The maintenance of sound (i.e. speech) exactly in step with movement in a visual image (i.e. faces). Because the processing time for the video portion of the signal is about 100 times longer than the audio processing time, codecs usually incorporate adjustable audio delay circuitry to delay/equalize the two signals, or regain lip sync.

LNA: Low Noise Amplifier - Refers to electronic equipment, used in conjunction with satellite reception, intended to amplify extremely weak satellite signals without introduction of noise

LNB: Low Noise Block - Downconverter, usually at the focal point of a satellite antenna; converts satellite frequencies to receiver frequencies (a type of LNC)

LNC: Low Noise Converter - Refers to equipment that combines an LNA and down converter in one package

LOOK-ANGLE: The angle at which an antenna must be aimed in order to "see" (i.e., receive the signal from) a particular satellite; also called the position angle.

LOOPBACK: Analog signals are easy to test. One simply probes the point of interest with an oscilloscope and checks for the proper signal. High speed digital signals complicate things because they can't be measured easily by traditional test equipment. To make tests easier, many digital equipment comes with loopback capability. Loopback diagnostics allow you to "instruct" a piece of equipment in your digital link to "echo" any information sent to it in the reverse direction. When properly looped back, the codec should echo (from the receiver output) any audio sent into the transmitter. By enabling loopback at different points on a network, the defective portion can more easily be determined.

LOSSLESS: Negligible signal loss

LOSSY: Something that causes a degradation of the signal - a lowering of the signal from the source to the end.

LPTV: Low Power Television - Stations which cover only 10 to 15 miles and are designed as "neighborhood" stations or ones that cater to a specific audience; LPTV is technically identical to television translators

LSBIC: Lake Superior Broadcast Instruction Council - One of the RETAs serving schools in the Channels 8 and 36 (Park Falls) television viewing areas and headquartered in Ashland

LUMINANCE: That portion of a composite video signal that represents the monochrome or brightness parts of the image

MATV: Master Antenna Television - An antenna system for a large number of TV sets such as a school, hotel or apartment building, where many sets receive a signal from one antenna

MDS: Multipoint Distribution Service - The commercial counterpart to ITFS, often referred to as "wireless cable" because it can be used to deliver pay television programming directly to homes. MDS subscribers must install microwave antennas to receive program transmissions.

MEET-ME-BRIDGE: A type of telephone bridge that provides dial-in conferencing. Can be accessed directly by calling a certain telephone number.

MHz: Megahertz - Refers to a frequency equal to one million Hertz, or cycles per second

Mbs: Megabits Per Second - A rate at which data/information may be transferred across a communications line; 1 Mbs equals 1,000,000 bits per second, or approximately 125,000 characters per second (assuming 8 bits per character)

MICROPROCESSOR: The heart of the computer. A silicon chip that processes data and controls the computer's components.

MICROWAVE: A high-frequency range used to transport audio, video and data signals point to point. A single transmit and receive link can cover up to 40 miles and requires clear line of sight.

MICROWAVE BAND: The band of frequencies, 1,000 megahertz or greater, that uses very short waves. These bands are used primarily for point-to-point communications.

MILWAUKEE PUBLIC SCHOOLS: One of the RETAs serving the ITFS Channel 9 area in Milwaukee

MMDS: Multichannel Multipoint Distribution System or MDS, Multipoint Distribution Service

MODEM: Modulator/Demodulator - An electronic device used to allow a computer to send and receive data, typically over a phone line

MODULATION: The process of encoding audio or video signals onto a radio wave for transmission

MONITOR: Generally a television display used specifically for the display of video information

MPEG: Motion Picture Experts Group - An ISO motion video and audio compression standard providing lossy or lossless compression. It is useful for playing back multi-media images from CD-ROM. Applications also extend to broadcasting and potentially videoconferencing.

MSO: Multiple System Operator - A cable company that owns several systems

MTS: Multichannel Television Sound - A narrowcast technology. In addition to providing stereo music, MTS provides another channel for data delivery, additional language services or supplementary instructional television services. Viewers need special equipment to receive MTS.

MULDEM: A piece of equipment which provides multiplexing and digital interface capability onto an optical (i.e. fiber optic) network.

MULTIPLEX: Process by which multiple signals are transmitted over a single channel

MULTIPOINT: A communications system which allows three or more sites to participate in the transmission

NANO: Prefix meaning one billionth (e.g., nanosecond)

NAPLPS: North American Presentation Level Protocol Standard - Used for videotext, allows presentation of high quality graphics

NARROWCASTING: As compared to "broadcasting" - television and radio designed to reach small, targeted audiences with an audio or video signal that is transmitted from a central point and can be received by persons around the transmitter using special radio and television equipment. ITFS, cable television, fiber optics and satellite are examples of narrowcast technologies.

NETWORK: A group of interconnected television or radio stations capable of simultaneous transmission of a given program

NETWORKING: The tying together of multiple sites for the reception and possible transmission of information. Networks can be composed of various transmission media, including copper wire, terrestrial microwave, or coaxial.

NEWIST: Northeastern Wisconsin In-School Telecommunications - One of the RETAs serving the Channels 20 and 38 areas headquartered in Green Bay

NEWTEC: Northeast Wisconsin Telecommunications Education Consortium - A group of school districts using ITFS for distance education and staff development in the Green Bay area

NIBS: Northwest Instructional Broadcast Service - One of the RETAs serving schools in the Channels 20 and 28 areas headquartered in Elmwood

NODE: A termination point for two or more communications links. The node can serve as the control location for forwarding data among the elements of a network or multiple networks, as well as performing other networking and, in some cases, local processing functions

NOISE: Noise is anything present between the codecs other than the binary signal being transmitted. (a) Audio - unwanted sound signals; (b) Video - electronic interference, snow, sparklies

NOISE FIGURE: Measurement of noise contribution of an amplifier relative to a noise-free amplifier at a reference temperature; usually expressed in dB

NOISE TEMPERATURE: Noise measurement of a system, as the absolute temperature of a resistive source delivering equal noise power; expressed in (degrees) Kelvin

NPR: National Public Radio

NSF: National Science Foundation

NSI: Nielsen Station Index

NTIA: National Telecommunications Information Agency, U.S. Department of Commerce

NTSC: National Technical Standards Committee - The transmission standard to which television in the US adheres; provides less picture quality than HDTV

NTU: National Technological University (Fort Collins, CO)

NUTN: National University Teleconferencing Network

NULL MODEM: A device which interfaces between a local peripheral that normally requires a modem, and the computer near it that expects to drive a modem to interface to that device; an imitation modem in both directions

NWECS: Northern Wisconsin Educational Communications System - A consortium consisting of UW Superior, Wisconsin Indianhead Technical College, the Superior Public Schools and CESA 12 - developing an interactive fiber optic network

OCLC: A computerized library database supplying bibliographic information to libraries across the nation

OCR: Optical Character Recognition or Optical Character Reader

ORIGINATION CAPABILITIES: Ability to send information (e.g. video, audio and graphics)

ORIGINATION SITE - The location from which the program is transmitted

OSHA: Occupational Safety & Health Administration

OSI: Open System Interconnection - Emerging standard for a layered architecture which allows data to be transferred among systems through networks

OTA: Office of Technology Assessment

PACKET SWITCHING: Digital transmissions are broken into data "packets" that are addressed to their destination and sent by a central switching computer along diverse routes through the network, taking advantage of pauses in voice conversations and interactive data transmissions; the packets are then reassembled at the destination switching center and sent to the end user.

PAL: Phase Alternation Line - The European broadcast standard used in United Kingdom, Germany and some other European countries

PARABOLIC DISH: A satellite antenna, usually bowl-shaped, that concentrates signals to a single focal point

PATH ANALYSIS: A calculation of gains and losses on a radio frequency path; an analysis of terrain and distance between ITFS transmit and receive sites is part of such analyses

PBS: Public Broadcasting Service

PBX: Private Branch Exchange - A telephone switch located on a customer's premises that primarily establishes voice grade circuits

PCB: Printer Circuit Board - An electronic assembly that is plugged into the main frame assembly of an electronic device

PCM/ADPCM: Pulse Code Modulation - This is the technique used by CD players and other devices to "digitize" audio. The codec converts PCM to Adaptive Differential PCM in order to conserve media bandwidth.

PE: Professional Engineer

PERT: Program Evaluation and Review Technique - A project management chart which plots the "critical path" of a project

PICTURE ELEMENT: The smallest discrete part of a video image, the size of which is controlled by an analog-to-digital conversion sampling process and subsequent other compression processes. The more picture elements per line, the higher the resolution of the image. To convert H Pixels to a close approximation of TV lines of resolution for the NTSC system, simply multiply the number of H pixels by 0.78.

PIP: Picture-in-picture display - A video display mode in which a one-quarter-size video image is superimposed over one quadrant of a full-screen video image

POLAR MOUNT: Antenna mechanism permitting steering in hour angle (i.e. along the GEO arc) by rotation about a single axis. Also Equatorial Mount. A classical polar mount has its axis parallel to that of the earth. TVROs use modified polar mount geometry incorporating a declination offset.

POLARIZATION: The property by which an electromagnetic wave exhibits a direction (or rotation sense) of vibration, giving the opportunity for frequency re-use by orthogonal polarizations. Four types of polarization are used with satellites: horizontal, vertical, right-hand circular, and left-hand circular.

POLAROTOR: A device that permits selection of one or two orthogonal polarizations, or of any polarization angle.

POP: Point of Presence - Locations at which a customer is able to connect to a carrier's network. Example: US Sprint has a POP for their fiber network in Auburn, IN.

PORT: Point of access to a computer or a computer network

POT: Potentiometer - Audio control knob

PRIME FOCUS: The focal point of a parabolic reflector; a feed system placed at that point

PROGRAM: With respect to a state agency, a set of duties or services uniquely assigned by law

PROJECT CIRCUIT: Trempealeau County Interactive Cable Network serving the county school districts

PROJECTION SYSTEM: A large screen system used to show video or television images

PROTOCOL: Refers to the communication parameters necessary to make a connection between computers (two examples are baud rate and duplex)

PROTOCOL CONVERSION: The process translating the protocol, native to an end-user device (e.g. a terminal) into a different protocol allowing that end-user device to communicate with another (e.g., a computer) with which it would otherwise be incompatible -

PSC: Public Service Commission

PTFP: Public Telecommunications Facility Program - of the NTIA. Funds from PTFP (and from an earlier version administered by what was then the Department of Health, Education, and Welfare) have built much of the public broadcasting system in this country, which includes a substantial portion of the state network facilities in Wisconsin.

RAM: Random Access Memory - The most common computer memory, the contents of which can be altered at any time

RAPID DEPLOYMENT SYSTEM: A bare-bones videoconferencing system, including codec, packaged in shippable containers and permitting rapid setup. This is intended for establishing videoconferencing in emergency and crisis situations

REAL TIME: Sending and receiving of messages occurs simultaneously without delay, "live". A transaction which occurs without significant delay from start to finish, i.e., taking a class from a "live" instructor and getting immediate feedback as opposed to watching a videotape of the class sometime after the actual event.

RECEIVE DISHES: See Downlink

RECEIVE-ONLY CODEC: A video codec configured so as to be able only to receive communications signals and process them for local output, for use at receive locations in point-to-multipoint or for broadcast applications where two-way codec communication with the sending location is not required

REDUNDANT: Video data information that does not change over time (temporarily redundant) or video data information where a given pixel is surrounded with similar pixels (spatially redundant)

RETAs: Regional Educational Telecommunications Areas - (See LSBIC, Milwaukee Public Schools, NEWIST, NIBS, SEWIST, SWECS, WWBIC) located throughout the state

RGB: A video signal where the red (R), green (G) and blue (B) picture components are present as individual signals. Synchronization information may be included with the G signal or may be separate.

RF: Radio Frequency - An electronic signal above the audio and below the infrared frequencies

RFB: Request For Bid - Written invitation to vendors of goods and services, used when the task, the options and procedures, and the components and order of work are well defined. It gives precise specifications required. Vendors respond with a formal sealed bid that includes specific prices; customer selects one bid.

RFI: Request For Information - Request to vendors of goods and services for information; for example, about how something could be done. It is used when there is little in-house expertise or when the need is conceptual. Vendors respond with general information and prices. Typically, a customer does not purchase from responses to an RFI but may use responses to develop a RFP or RFB.

RFP: Request For Proposal - Invitation to vendors of goods and services - used when the best option may be in doubt, and to gain information on cost effectiveness of various options. It describes what the customer wants to do and any constraints or conditions. Vendors respond by describing how they would do it, what they would provide and the price they would charge. The customer reviews the responses and selects a vendor.

RFQ: Request For Quote - A shorter, less formal RFB used to replace specific equipment or to purchase one-time services or service contracts

RJ-11: A standard modular telephone jack

ROM: Read-Only Memory - A type of semi-conductor memory device that stores unalterable data or program information

RS-232C: The industry standard for a 25-pin interface that connects computers with various forms of peripheral equipment; i.e., modems, printers, etc.

SAP: Separate Audio Program - A second audio channel available with every TV channel under the NTSC standard. Often used for bilingual teaching where the SAP channel carries program audio in a different language from the main audio channel.

SATELLITE: Electronic space vehicle located in a fixed geostationary orbit used to retransmit signals from one location on the earth's surface to one or more locations.

SATELLITE TIME: The amount of time booked on a communications satellite, usually in one-hour intervals

SCA: Subsidiary Communications Authorization - An additional program channel which can be transmitted along with the regular stereo programming of an FM station

SCHOOL RADIO SERVICE: Transmitted by SCA (Subsidiary Communication Authorization) Radio, "piggy backed" with FM radio signals and received by special receivers

SCRAMBLER: A device that alters a picture so that it cannot be viewed on a home screen without a decoder

SDN: Software-Defined Network - A virtually private network in which the network links are assigned to users as needed and typically are invoiced on the basis of bandwidth and time occupancy

SECAM: Sequential Couleur Avec Memoire - European broadcast standard used in France and (the former) U.S.S.R.

SEND-ONLY CODEC: A video codec configuration so as to be able only to originate and transmit communications signals, for use at the sending location in point-to-multipoint or for broadcast applications where 2-way codec communication with the receiving location(s) is not required

SERC: Satellite Educational Resources Consortium - A partnership of state education departments and state broadcasting networks in 19 states and 3 cities, serving students and teachers with live, interactive distance learning courses via satellite and, in Wisconsin, retransmitted via ITFS. The Department of Public Instruction and the Educational Communications Board are members of SERC.

SERVICE AREA: The region in which a broadcasting or narrowcasting station signal can be received with satisfactory results

SEWIST: Southeastern Wisconsin In-School Telecommunications - One of the RETAs serving Channel 36 area headquarters in West Allis

SIDELOBE: Off-axis response of an antenna

SIGNAL-TO-NOISE RATIO: Relative quality measurement of video, audio or RF measured in decibels

SIMPLEX: A wire, channel or carrier frequency that can accommodate only one message in one direction at a time - Example: broadcast TV channel

SMATV: Satellite Master-Antenna Television - A pay-TV service delivered to roof-top earth stations located on multi-dwelling units, and then distributed to individual apartments by coaxial cable - also called "private cable"

SMPTE: Society of Motion Picture and Television Engineers

SOFTWARE: Programs, procedures and related documentation associated with a computer system; sometimes used to refer to TV programming

SONET: Synchronous Optical Network - An emerging interface standard for fiber optic networks' digital signalling transmission and equipment. SONET will allow the switching of fiber optic links to be done more easily (using direct optical switches and cross-connects, and will allow mid-span bridging). It will obviate the need for many of the electronic multiplexing components now required at signal generation and switch points. Initial implementation expected within 6 years in Wisconsin.

SNR: Signal-to-Noise Ratio - A measure of how clean (noise-free) the recovered baseband signal is

STA: Special Temporary Authorization from the FCC

State: State of Wisconsin

STL: Studio-to-Transmitter Link - Any technical method to get a signal from a studio to a transmitter such as coaxial cable and point-to-point microwave

STS: State Telephone System

STUDIO: A room containing camera, microphones and other television or radio equipment necessary to originate a signal

SWECS: Southern Wisconsin Educational Communications Service - One of the RETAs serving the Channel 21 area headquartered in Madison

SWITCH: Any mechanical or solid state device that opens or closes a circuit, changes parameters, or selects paths or circuits

SWITCHED-56: A service available from local telephone companies which offers a digital channel interface at a 56 Kbs rate. Allows the user to place calls between several points and cut costs by only paying for part time service. Generally used for computer data transmission or compressed video teleconferencing. Functionally equivalent to a DS-0.

SWITCHING: Process of routing communications traffic from a sender to the correct receiver (e.g. telephone switchboard)

SYNCHRONICITY/SYNCHRONOUS: "Live" or "real time" transmission and reception (e.g., audio teleconferencing)

SYNCHRONIZATION: Many data networks simply provide a bit stream to the user, without any information on how to divide these bits into "words". Some networks use overhead bits to determine the "start" and "stop" of each work. If the codec is to give you the best possible use of your data channel, it can't afford the overhead required to provide alignment information if it isn't provided by the network. For this reason, the codec's receiver takes in raw, unframed data and analyzes it to determine the proper word alignment. This auto synchronization scheme allows the receiver to frame words with no other information. In the case where you are communicating with a less sophisticated codec, the transmitter may be configured so that output words line up with network timing information, if available. This assures that the other codec will receive words aligned with the network timing.

SYSOP: System Operator - Usually on a computer bulletin board

T-1: Telephone term given to a digital transmission circuit whose bandwidth is equal to 24 DS-0 voice channels or 1536 Kbs (actually, 1544 Kbs with 8 Kbs bits used for overhead)

T-3: A carrier of 45mb/s bandwidth; one T-3 channel can deliver 28 T-1 channels, or 672 voice circuits used for digital video transmission or for major PBX-PBX telephone interconnection

TA: Terminal Adapter - A CSU/DSU for an ISDN line. Its function is actually to adapt non-ISDN equipment to the ISDN user rate. It may also provide you with a choice of bearer services which determine the type of ISDN call you will make. For the most part, the codec requires the placement of a 56 or 64 Kb/s clear channel data call.

TARIFF: A published rate for services provided by a common or specialized carrier. The means by which regulatory agencies approve such services - the tariff is a part of a contract between customer and carrier.

TBC: Time Base Corrector - A device used in conjunction with a playback from a VCR to provide sufficient timing stability to permit successful encoding of the video signal by the codec. Some codecs include a built-in TCB.

T-CARRIER (T-1): A hierarchy of digital systems designed to carry speech and other signals in digital form, designated T-1, T-2 and T-4. The T-1 carrier has 24 channels and transmits at 1.544 megabits per second. The T-2 carrier has 96 channels equivalent with a 6.312 megabit line rate. The T-4 carrier transmits 274 million bits per second.

TDM/TDMA: Time Division Multiplex/Multiple Access - A method for combining multiple data circuits into one circuit (or vice versa) by assigning each circuit a fixed unit of time for its data transmission

TELCO: Acronym for Telephone Company

TELECOMMUNICATIONS: The exchange of information such as video, voice or data, using electromagnetic signals in digital or analog form

TELECONFERENCE: A method for multiple sites separated by some distance to be linked together for the purpose of communication with each other - this can be done using voice only (a "conference call"), voice and picture (a "video teleconference") or voice, picture, and data.

TELEPHONY: Transmission of speech or other sounds

TELETEXT: Systems that transmit a text and graphics "magazine" to TV sets equipped with special decoders which allow users to select individual pages; most decoders include hand-held remote control keypads

THRESHOLD: The minimum signal-to-noise input required to allow a video receiver to deliver an acceptable picture

TIME-SHIFTING: Recording broadcast or cablecast programs on a videocassette recorder for playback at a more convenient time

TOC: Telecommunications Operation Center - at ECB

TRANSLATORS: Radio or television broadcast stations, operating at relatively low power, that receives a broadcast signal on one channel, amplifies it and retransmits it on another channel

TRANSPARENCY: A term which signifies that a network user essentially has no need for awareness of the specific network characteristics or components in use to transfer the required information

TRANSPONDER: The antenna-like part of the communications satellite that receives signals from the earth, translates and amplifies them, and retransmits them back to earth. Satellites have numerous transponders, typically 32.

TRANSPONDER EARTH STATION: Earth stations that are mounted on trailers and can be moved from site to site

TTL: Transistor-Transistor Logic - A type of integrated circuit with logic levels of +5V and 0V. These logic levels are often specified for digital signals that connect to the codec

TVRO: Television Receive Only - Earth station equipment that receives video signals from satellite or MDS-type transmissions. Such stations have only receiving capability and need not be licensed by the FCC unless the owner wants protection from interference. Authority for reception and use of material transmitted must be given by the sender.

TWISTED PAIR: A cable composed of two small insulated conductors twisted together without a common cover. The two conductors are usually substantially insulated so that the combination is a special case of the cord. Telephone signals are the most common use of twisted pair technology.

TYMNET/TELENET: Commercial packet-switched networks available in major cities by direct dialing

UHF: Ultra High Frequency - Received on broadcast television Channels 14 through 83

UNIX: A computer operating system

UPLINK: The transmission power that carries a signal or material from its earth station source up to a satellite

UPSTREAM/DOWNSTREAM: Cable industry jargon indicating whether a signal is traveling from the "headend" of a two-way cable system to the subscriber (downstream) or in the opposite direction

UW: University of Wisconsin

UWEX: University of Wisconsin-Extension

UWS: University of Wisconsin System

VALUE ADDED SERVICE: A communication service utilizing communications common carrier networks for transmission, providing added data services with separate additional equipment. Such added service features may be store and forward message switching, terminal interfacing, and host interfacing.

VBI: Vertical Blanking Interval - Transmitted as a part of the television video signal (in the black "bar" that can be seen at the top of the television picture); the FCC has granted commercial and public television stations the right to use the VBI for computer data transmission, software delivery (also called "telesoftware"), teletext, and paging services.

VCR: Videocassette (Cartridge) Recorder - Device which uses special magnetic tape to record both audio and video portions of a television production for replay

VHF: Very High Frequency - Refers to Electromagnetic waves between approximately 54 MHz and 300 MHz

VHS: Video Home System - The more popular of the two types of videocassette recorders

VIDEO: The demodulated and displayed electronic signal which is reconstructed as a viewable picture by a transducer, such as a TV set. The picture is extracted from an analog or digitally encoded carrier wave used to facilitate transmission.

VIDEOCONFERENCING: Using video and audio links to hold a meeting among participants at different locations. Videoconferencing is a form of teleconferencing, which is holding meetings electronically. When only voice links are used, the meeting is an audioconference.

VIDEODISC: Uses a laser to read information that has been encoded in a series of microscopic pits engraved in the disk. Disks permit precise and rapid access to individual frames or sequences of images, and have huge storage capabilities; one side of a disk can contain 54,000 distinct images of frames. Can be used for interactive video.

VIDEOTEX: An interactive data communications application designed to allow unsophisticated users to converse with a remote database, enter data for transactions, and retrieve textual and graphics information for display on subscriber television sets or (typically) low cost terminals

VIRTUAL PRIVATE NETWORK: Term used by US Sprint to designate their SDN product offering -MCI's designation is "VNET"

VOICE GRADE CHANNEL: A channel used for speech transmission usually with an audio frequency range of 300-3300 hertz. It is also used for transmission of analog and digital data. Up to 10,000 bits per second can be transmitted on a voice grade channel.

VSAT: Very Small Aperture Terminal - Small earth stations, usually 4 feet to 6 feet (1.2 meters to 1.8 meters) in diameter

VSWR: Voltage Standing Wave Ratio - A measurement of mismatch in a cable, waveguide or antenna system

VS-3: Model number of the Grass Valley equipment that can be used to distribute/switch video signals between the fiber backbone links

VTAE: Vocation, Technical and Adult Education

WAACE: Wisconsin Association for Adult and Continuing Education

WAICU: Wisconsin Association of Independent Colleges and Universities - Located in Madison

WANUC: Wausau Area Narrowcast Users Consortium - ITFS group comprised of vocational/technical K-12 and University users

WASB: Wisconsin Association of School Boards

WASCD: Wisconsin Association for Supervision and Curriculum Development

WASDA: Wisconsin Association of School District Administrators

WATS: Wide Area Telecommunications Service - A bulk rate long-distance telephone service

WAVEGUIDE: A transmission line comprised of a hollow conducting tube of guided electromagnetic waves

WDM: Wavelength Division Multiplexing - A term which signifies use of an optical filtering technology which allows bi-directional information flow on the same fiber using two separated wavelength bandwidths within which each information path is transported to its respective direction of flow

WEAC: Wisconsin Education Association Council

WECB: Wisconsin Educational Communications Board (see ECB)

WEMA: Wisconsin Educational Media Association

WestWING: West Wisconsin Instructional Network Group - A group of schools and institutions in the St. Croix County region who are developing an interactive video-audio network for instructional purposes

WICORTS: Wisconsin Interagency Committee on Radio Tower Sites

WIN: Wisconsin Indianhead Narrowcast Network - A group of schools and the Wisconsin Indianhead Technical College-Rice Lake Campus, using an ITFS system

WIND LOADING: The pressure placed upon a TVRO antenna by the wind. Well-designed satellite antennas should be able to operate on 40-mph winds without noticeable picture degradation and be able to withstand winds of up to 125 mph.

WIRELESS CABLE: - The use of frequencies in the MDS (Multipoint Distribution Service), MMDS (Multichannel Multipoint Distribution Service), OFS (Operational Fixed Service) ranges, reserved by the FCC for commercial use, sometimes along with ITFS frequencies, to form a transmission service, typically for entertainment programming

WISCAT: Wisconsin Catalog - CD-ROM union catalog developed and maintained by the Department of Public Instruction. It includes 4 million unique records from over 250 Wisconsin libraries, public, K-12 and postsecondary.

WISCNet: Statewide data network serving higher education. Acts as a gateway to Internet. It includes all UW system campuses plus 8 colleges and universities in the state.

WISENet: An electronic bulletin board and mail system maintained by DPI - it is available through dial-up to an 800 number

WISLINE: Teleconferencing bridge (connection) offered by UW-Extension's Instructional Communications Systems. Permits up to 68 people to be connected with each other for a teleconference.

WIsNet: A regional computer network providing educational entities with access to Internet, a national computer network and its resources, including national supercomputer centers, library catalogs and data repositories

WISPLAN: UW-Extension computer service providing agricultural "decision aid" programs, electronic mail and other services to Extension staff and their clients

WISPP: Wisconsin Strategic Planning Project - A project of the Department of Administration designed to help state agencies develop strategic business plans and strategic information technology plans, and to develop a comprehensive statewide information technology plan

WisSat: A system of satellite dishes located at county courthouses, provided by UW Extension's Cooperative Extension to be used for educational purposes

WisView: An audiographics system for education programs that combines interactive audio with visual computer graphics, provided by UW Extension's Instructional Communications Systems.

WITS: Wisconsin Independent Telecommunication Systems

WSTA: Wisconsin State Telephone Association

WWBIC: Western Wisconsin Broadcast Instruction Council - One of the RETAs serving the Channel 31 area headquartered in Onalaska

X.25: A set of packet switching standards published by the CCITT

XLR: A 3-conductor shielded round connector commonly used in professional applications for connection of low-level balanced audio signals to equipment.

.GLOSSARY.ECB